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THE SOCIO-BIOLOGY OF MAN

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WHAT is man as a biological being? What is man as a social being? What is man regarded as a function of both a biological and a social structure in interaction? These are the questions to which I shall attempt to return an answer. I propose to make no vague generalizations concerning the social and biological functions of human beings, but rather to attempt to relate the more fundamental of man's biological and social functions—concerning which reliable knowledge is available—to the world in which human beings exist at the present time; to indicate what the nature of those functions is; to point out how they have been understood and formed up to the present time, and finally, to suggest the nature of the principles which must be recognized if "Nature's sole mistake," as one unsympathetic philosopher has termed man, is to be turned into a success.

In the study of any organism it is always desirable to remember that the organism exists as a whole, and not merely as a series of parts which may be studied in dissociation from one another in atomistic fashion—as if such parts had any meaning apart from their relation to the whole organism. Yet this is a principle which has often been forgotten or neglected by numerous investigators in the pursuit of their studies, and its neglect has been the occasion of much confusion in scientific thought. Nowhere is the confusion thus engendered more apparent than in the fields of study relating to man in society. An instance of this, with which many will be familiar, is the practice of drawing inferences concerning the native ability of individuals on the basis of ratings derived from intelligence tests without taking into consideration the very necessary factors of the social and economic history of the individuals tested in this way. Or to quote another instance, there is the oft-repeated assertion that so-called primitive peoples are mentally inferior to ourselves because they have not developed a culture which can compare with ours. These are typical examples of inferences which are drawn from particular aspects of phenomena without any reference to the framework as a whole of which they form a part. When the whole, in such connections, is considered and understood, the real significance of the integrated part becomes unequivocally clear; and that significance is very different from that which is attributed to the part when it is not so considered in relation to the whole.

So, here we shall take mankind as a whole for our province, and consider its fundamental social and biological functions of a whole, or series of whole frameworks, and where we encounter significant differences—as we shall—we shall

attempt to explain them in terms of the whole to which they relate. In this way we may perhaps arrive at some common principles which may apply to man universally and in all societies.

The first point concerning which it is necessary to be clear is the position of man in the world as an animal organism. Upon this elementary point there strangely seems to exist a considerable amount of confusion. It is often stated that man is descended from a monkey or variously from the gorilla or the chimpanzee. In such statements there is not an ounce of truth. Man in common with these animals belongs to the same Order of Mammals, the Order of Primates, but his kinship with the monkeys is very remote, while his relationship with the African anthropoids, the chimpanzee and the gorilla, is collateral and not linear. That is to say, though the anthropoids and man were probably derived from the same stock, their evolutionary history has proceeded along disparate and divergent lines. Thus, man is not descended from any existing anthropoid ape, but from the same stock as that from which the anthropoids also originated; hence, they may be regarded as at most collateral relatives or very distant cousins, and from the standpoint of the modern zoologist, members of the same extended family. Fossil remains of an animal from which man and the anthropoids may have originated are known from the Miocene horizons of the Siwaliks of India, namely, the remains of *Sivapithecus sivalensis*. *Sivapithecus* is known only from some fragments of upper and lower jaws and a good assortment of teeth, but these represent among the most valuable of the remains of any animal. Comparison of these remains with the similar parts of anthropoids on the one hand, and human beings on the other, suggests that man has become a less specialized form, while the anthropoids have become comparatively excessively specialized. The moderately developed canine teeth of *Sivapithecus* have in man been replaced by a tooth the tip of which is almost level with the biting surfaces of the rest of the teeth, whereas, in the anthropoids, these teeth have been replaced by great tusk-like structures.

There is a lesson which suggests itself here, and it is, I believe, a perfectly legitimate one to draw from the evidence. The lesson is that specialization is achieved at the cost of general efficiency and leads to a constriction of the process of living or experiencing; whereas a general and well-integrated distribution of energies leads to an increase in general efficiency and an enlargement of the capacity to live and experience. And this, essentially, is the difference between the apes and man. The apes have pursued a developmental course which will ultimately lead to their extinction. They are too narrow, too specialized. They can not compete with man. The human species, on the other hand, has pursued a developmental course which has been characterized by its plasticity and adaptability, a plasticity and adaptability which has led mankind to the position in the world in which it now finds itself. Not "Nature's sole mistake," at least, not yet, but nature's most spoiled brat, perhaps; unquestionably nature's most promising child. It need hardly be pointed out that spoiled brats and promising children are conditions frequently found together in the same individual. In terms of zoologic time, and in terms of experience, mankind is still in the childhood of its development. Of the future we can say very little. As a friend of mine, a garbage collector, once appropriately remarked, "If we take care of the present the future will take care of itself." The time for lamentation and jeremiads may safely be postponed to the end of the next half-million years,

when the original readers of this paper and its author may possibly figure in the cases of the Museum of the University of Pennsylvania as the fossil representatives of a race that thought it could beat the Philadelphia city tax on incomes—and maybe did!

This plasticity and adaptability which so conspicuously endows man, beyond all other animals, with the ability to control so much of the world in which he lives, is reflected both in the structure of his body and of his mind. Both are the least specialized of any to be found in the Order of Mammals to which he belongs. Now, this is an extremely important point to grasp; that is, that biologically man is both structurally and mentally the most plastic and adaptable animal in existence. Structurally, this plasticity has enabled him to adapt himself to an untold variety of conditions. Upon his inner genetic resources he has been able to draw for combinations of physical characters which have met the requirements of natural, sexual and social selection, which, as factors operating in geographically isolated localities have been instrumental in producing the varieties of man with which we are acquainted. Whether these varieties of man represent the effects of the action of mutant genes, of natural, sexual or social selection, or any combination of such factors, the outstanding fact remains that the group has varied in the way it has structurally without in any way losing its plasticity; indeed, there seems to have been a very definite gain in plasticity and adaptability.

And here the important fact requires to be stated that all varieties of man belong to the same species, and without a doubt have the same common human ancestry. This is the conclusion to which all the relevant evidence of comparative anatomy, hematology and genetics points. On genetic grounds alone it is virtually impossible to conceive of the varieties of man having originated separately as distinct lines from different anthropoid ancestors. Genetically, the chances against such a process ever having occurred are in mathematical terms of such an order as to deny the suggestion even so much as a glimpse into the universe of possibility. On anatomical grounds the evidence is quite clear. The physical differences which exist between the varieties of mankind are, from the anatomical standpoint, so insignificant that when properly evaluated they can only be defined in terms of a particular expression of an assortment of genes which are common to all mankind. And this one may say very much more definitely and with much greater justice than one may say it of the differences exhibited by any of our domesticated varieties of cats, dogs or horses. There are numerous varieties of cats, dogs and horses, and these represent highly selected strains of animals which have been bred as more or less pure breeds and domesticated by man. Man too is a domesticated, a self-domesticated, animal, but unlike our domestic animals the varieties of man are much mixed and are far from representing pure breeds. The range of variation in all human varieties for any character is very much more considerable than that which is exhibited by any group of animals belonging to a pure breed. All the evidence indicates that the differences between the so-called "races" of man merely represent a random combination of variations derived from a common source which, by inbreeding in isolated groups, has become more or less stabilized and hereditary in a large number of the members of such groups. Furthermore, the evidence indicates that such selection of variations as has occurred in different groups has been restricted entirely to physical characters. There is no evidence among the varieties of mankind that any process of mental selection has ever been operative. The conception of selection for mental quali-

ties seems to be a peculiarly modern one, adapted to modern prejudices.

Man has bred dogs for certain temperamental qualities useful in the hunt—dogs like the Irish setter, for example. The Irish setter is always red-haired, but his red hair has no connection with his temperamental qualities. Yet his hair color is often used as a tag or label for his temperamental qualities. The Irish setter has the same kind of temperament as the English setter, but the hair color of the English setter is white and black. The only difference between white, black, white *and* black and red setters lies in their coat color, and none at all in their mental or temperamental qualities. No one ever asks whether there are temperamental differences between white, black or brown horses—such a question would seem rather silly; but when it comes to man the prejudice of any one who has ever made the statement that skin color is associated with mental capacity is accepted as gospel. For such an assumption there is about as much justification as there would be for the assumption that there exist substantial mental differences between the differently colored varieties of setters. We know this to be false for setters *only* because we have paid more attention to the character of the mental qualities of dogs than we have to those of human beings. But those of us who have paid some attention to the character and forms of the mind of peoples belonging to different varieties of mankind and to different cultures have satisfied ourselves, by every scientific means at our disposal, that there exist no significant or demonstrable innately determined mental differences between the varieties of mankind. There is every reason to believe that such mental differences as we observe to exist between the different varieties of man are due entirely to factors of a cultural nature, and are in no significant way related to biological factors.

A question often asked is: Why do the cultures of different varieties of man differ so considerably from our own? The answer is really quite simple. Cultures differ from one another to the extent to which their experience has differed. No matter with what variety of mankind we may be concerned, or with what groups of a particular variety, culture is in its broadest and fundamental sense not merely an aspect but a function of experience. By experience I mean anything that an individual or group of individuals, has undergone or lived, perceived or sensed. The reason why the cultures of different varieties of man are so different from our own is that these varieties have been exposed to experiences which differ as considerably from our own as do the cultures in question. If you or I, with our present genetic background, had been born and brought up among a group of Australian aborigines we should have been, culturally, Australian aborigines, though physically we would remain members of our own variety. For experience is determined by the place and culture in which groups and individuals live, and it is for this reason that groups and individuals belonging to different cultures will differ mentally from one another. Our physical structure would not have varied because it was genetically determined by our present parents, but our cultural equipment would have been that of an Australian aboriginal. Why? Because culture—and by culture I understand social behavior and all its products—because culture is something that one acquires by experience, unlike one's physical appearance, which one acquires through the action for the most part of inherited genes; and the culture of individuals, as of groups, will differ according to the kinds of experience which they have undergone. The culture of different peoples, as of different individuals, is to a very large extent a reflection of their past history or experience. This is a

point which is worth more than laboring, for if the cultural status of any variety of man is merely determined by the kind of experience which it has undergone, then it is evident that by giving all people the opportunity to enjoy a common experience—supposing for the moment that this were desirable—all would become culturally and mentally equal; that is, equal in the sense of having benefited from exposure to the same kind of experience; and always, allowing, of course, for the fact that no two individuals can ever be alike in their reception and reaction to the same experience, and that there will always, very fortunately, continue to be great differences between individuals. There can be very little doubt that genetic differences in temperament and intellectual capacity exist between the individuals comprising every variety of mankind, no two individuals in this respect ever being alike, but it takes the stimulus of a common experience to bring these out and to render them comparable. It is because of differences in cultural experience that individuals and groups differ from one another culturally, and it is for this reason that cultural achievement is an exceedingly poor measure of the value of an individual or of a group. For all practical purposes, and until evidence to the contrary is forthcoming, we can safely take cultural achievement to be the expression merely of cultural experience. Obviously, all learned activities are culturally, and not biologically, determined, whether those activities be based upon instinctive urges or traditional practises. The generalized urges which all human beings in common inherit continue to be present in all human beings in all cultures, but how these urges are permitted to operate, and how they are satisfied is something which is determined by tradition and varies not only in different cultures but in different groups within the same culture. For example, one of the fundamental urges which we all inherit is the urge to eat. Now, different human groups, to whom the same foodstuffs may or may not be available, not only eat different foods, but prepare them in unique ways, and consume them with or without implements in a variety of different styles, and usually for no better reason than that it is the customary practice to do so. The faculty of speech is biologically determined, but what we speak and how we speak is determined by what we hear in the culture in which we have been culturalized. Human beings everywhere, when they are tired, experience a desire to rest, to sit down, to lie down or to sleep, but the manner in which they do all these things is culturally determined by the custom of the group in which they live. Many other instances will doubtless occur to the reader's mind. The point to grasp here is that even our fundamental biological urges are culturally controlled and regulated or culturalized, and their very form and expression, not to mention their satisfaction, moulded according to the dictates of tradition.

In view of the tremendous number of different cultural variables which enter into the structure and functioning of different groups and the individuals comprising them, it is surely the most gratuitous, as it is the most unscientific, of procedures to assert anything concerning assumed genetic conditions without first attempting to discover what part these cultural variables play in the production of what is predicated. Obviously, no statement concerning the mentality of an individual or of a group is of any value without a specification of the environment in which it has developed. The introduction of the *deus ex machina* of genetics to account for the cultural differences between people may be a convenient device for those who must do everything in their power, except study the actual facts, in order to find some sort of support for their prejudices, but it is a device which

will hardly satisfy the requirements of an efficient scientific method. Such devices must be accepted in a charitable spirit as the misguided efforts of some of our misguided fellows to conceal the infirmities of their own minds by depreciating the minds of others. John Stuart Mill, almost a hundred years ago, in 1848, in his "Principles of Political Economy," put the stamp upon this type of conduct very forcibly; he wrote, "Of all the vulgar modes of escaping from the consideration of the effect of social and moral influences on the human mind, the most vulgar is that of attributing the diversities of conduct and character to inherent natural differences." While the number of people guilty of this vulgar error have greatly increased since Mill's day, the fraction of people who know it to be false has also greatly increased, and there is no need of despair for the future. The facts which are now available concerning the peoples of the earth render it quite clear that they are all very definitely brothers under the skin.

It would perhaps be too much to expect those who have been educated in the contrary belief to accept such a view, but the least we could do would be to provide the children in our schools with an honest account of the facts, instead of filling their guiltless heads with the kind of prejudices that we find distributed through so many of the books with which they are provided. Surely, a sympathetic understanding of people who behave "differently," and who look "differently," can not help but broaden one's horizons, and lead to better human relationships all round? Socially, this is, of course, greatly to be desired, but it can hardly be said that much has yet been achieved in this direction. There is here, obviously, a great deal of work to be done.

But let us return to our main discussion, for though school children and others have frequently heard of physical relativity, few if any children, and hardly any others, ever encounter the concept of cultural relativity. From the standpoint of the well-being and happiness of mankind the latter is a vastly more important conception to grasp than the former. By cultural relativity I mean that all cultures must be judged in relation to their own history, and all individuals and groups in relation to their cultural history, and definitely not by the arbitrary standard of any single culture such, for example, as our own. Judged in relation to its own history each culture is seen as the resultant of the reactions to the conditions which that history may or may not record. If these conditions have been limited in nature, so will the culture reflecting their effects. If the conditions have been many and complex in character, then so will the culture be. Culture is essentially a relation which is the product of the interaction of two correlates, the one a plastic, adaptable, sensitive, biological being; the other, simply —experience. If we agree that mankind is everywhere plastic, adaptable and sensitive, then we can only account for the mental and cultural differences between the varieties of mankind on the basis of a difference in experience. And this, when everything is taken into consideration, seems to be the true explanation of the mental and cultural differences which exist between the varieties of man. Let me give one or two examples of cultural relativity, as it were, in action.

Five thousand years ago the ancestors of the present highly cultured peoples of Europe were savages roaming the wilds of Europe. The ancestors of the modern Englishman were living in a Stone Age phase of culture, painting their bodies with woad and practicing all sorts of primitive rites, and culturally about equivalent to the Australian aboriginal—a state in which they continued for more than three thousand years until their discovery and conquest by the Romans

in the first century of our era. Five thousand years ago Europe was inhabited by hordes of savages, at a time when the kingdoms of Africa and the Babylonian empire were at their height. Babylon has long since passed into history and the kingdoms of Africa have undergone comparatively little change; but five thousand years ago, and less, the natives of these great cultures could have looked upon the Europeans as savages equal to beasts and by nature completely incapable of civilization—and hence, better exterminated lest they pollute the blood of their superiors! Well, whatever sins the Europeans have since committed, they have at least shown that given a sufficient amount of time and experience they were capable of civilization to a degree not less than that to which Babylon and the kingdoms of Africa attained.

Here we have an example of cultural relativity. If we use time as our framework of reference and say "The Africans have had a much longer time than we have had to develop culturally as far as we have—why haven't they?" The answer is that time is not a proper measure to apply to the development of culture or cultural events; it is only a convenient framework from which to observe their development. Cultural changes which, among some peoples, have taken centuries to produce, are among other peoples often produced within a few years. The rate of cultural change is dependent upon a multiplicity of different things, but the indispensable and necessary condition for the production of cultural change is the irritability produced by the stimulus of new experiences. Without the irritability of such new experience cultural change is exceedingly slow. Hence, if new experience is the chief determinant of cultural change, then the dimension by which we may most efficiently judge cultures is that of the history of the experience which has fallen to the lot of the cultures observed. In other words, to evaluate cultural events properly one must judge them by the measure of experience viewed through the framework of time. We, of the Western world, have packed more experience into the past two thousand years than has probably fallen to the lot of the Australian aborigines and other peoples throughout their entire history. Hence, any judgments of value we may attempt to make as between our own culture and that of other peoples will be quite invalid unless they are made in terms of experience. Bearing this cardinal principle in mind, we shall be able to steer a clear course.

If, then, the essential physical differences between the varieties of mankind are limited to superficial characters such as skin color, hair form and nose form, and the cultural and mental differences are due merely to differences in experience, then from the socio-biological standpoint all the varieties of mankind must be adjudged as fundamentally equal; that is to say, biologically as good and efficient as one another and culturally potentially equal. All normal human beings are everywhere born as culturally indifferent animals, and they become culturally differentiated according to the social group into which they happen to be born. Some of the culturally differentiating media are neither as complex nor as advanced as others; the individuals developed within them will be culturally the products of their cultural group. As individuals they can no more be blamed or praised for belonging to their particular group than a fish can be either blamed or praised for belonging to his particular class in the vertebrate series. Culture, the culture of any group, is more or less determined by accidental factors which the group, as a group, has usually done little to bring about. The more advanced cultures have merely been luckier in the breadth of their experience, their contacts, than the less advanced cultures.

Culturally most people have solved the problems with which they have been confronted very satisfactorily—each in his own way—and the chief difference between a primitive and an advanced culture seems to lie in the number of problems which have been created and in the number and variety of the attempts made to solve them. Quantitatively, the number of problems with which the average individual in Western civilization has to grapple are far more numerous than those with which any member of a simpler society must deal—but it is doubtful whether he is for that reason to be regarded as a better human being than such a member of a less advanced society. The average product of the Machine Age is hardly an achievement of which to be proud.

In judging cultures it is not so much the *quantity* of experience that matters as the *quality*. A little experience of the right quality is vastly more important for human happiness than a large quantity of experience of the wrong quality. When the quantity begins to outstrip the quality there is a serious danger of quality going under altogether. We of the Machine Age are faced with such a danger. In spite of our enormous technological advances we are spiritually, and as humane beings, not the equals of the average Australian aboriginal or the average Eskimo—we are very definitely their inferiors. We lisp noble ideals and noble sentiments—the Australians and the Eskimos practice them—they neither write books nor lecture about them. Theirs are the only true democracies, where every individual finds his happiness in catering to the happiness of the group, and where any one who in any way threatens the welfare of the group is dealt with as an abnormality. In Western civilization untold millions of individuals are now engaged in catering to the welfare of a relatively few powerful individuals at the cost of their own welfare and happiness. There seems to be a strange confusion of values here, and it is in the nature of the confusion that the victims are unable to see the cause of it. When men take advantage of their natural democratic rights to advantage themselves at the expense of others—and therefore of the group—the development of the group ceases to be associated with the principle of the greatest good of the greatest number; and it is, I suggest, because we, as individuals, have lost sight of the very existence of this principle that Western civilization is to-day threatened with a bankruptcy of the spirit. Let us learn, before it is too late, from those civilizations which were dominated by ruling castes who cared more about the preservation of their own privileges than for the good of the community, and which, becoming top-heavy, collapsed and perished. At the present time there remains one bank that still remains solvent in a gold-forsaken land where the prevailing religion is moneytheism; it is the Bank of Scientific Humanism. Its capital is unlimited, and it seeks clients who are willing to invest in human welfare and happiness. Let us draw upon this capital of ideas, not to hoard them, but to spend them wisely, and thus by our acts disseminate the currency of scientific humanism with which the happiness of mankind may be secured.

SCIENCE AND CULTURE

By LAWRENCE K. FRANK

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THERE is a growing interest in the relation of science to society as evidenced by the increasing number of public discussions, papers and books focussed on this question. For the most part these discussions are concerned with applied science and technology or are carried on in terms of large abstractions, such as Science and Society, with a capital S. Little attention is being given to the influence of scientific advances upon the traditional Western European culture upon which our society and our personal lives are organized.

Discussion of this topic is difficult because at present we have so few clear ideas and little or no adequate terminology. Indeed, it may be said that we are only just beginning to gain an awareness of culture, a realization that we live in a culture and, as we shall point out later, that culture is in us. In offering this discussion, therefore, it is hoped that the reader will be patient if it seems somewhat circuitous and at times puzzling. If, however, we are seeking some understanding of the meaning and significance of science for culture, we must first seek a clearer picture of what culture means and does.

Man as an organism exists along with all other organisms in the geographical world of physical, chemical and biological events and processes that we call nature. Throughout the long period of animal evolution every other species has come to terms with nature by differentiation and specialization of structures and functions for its life zone or environment. The persistence of some forms seemingly unchanged from the more remote horizons of geological time is convincing evidence of the effectiveness of these adaptations for survival. It is also eloquent testimony to the price that has been paid for survival on these terms because it has involved fixity and sacrifice of any further developmental changes.

Man, as we are beginning to realize, is unique because, unlike all other species, he has made his adaptations, not by organic specialization and bodily differentiation, but through ideas and the use of tools, whereby he has retained his organic plasticity, remained biologically young, unspecialized and capable of continued development.[1] Until we pause and reflect on this human mode of adaptation, we may not realize the full significance of what man has attempted. Instead of accepting one of the innumerable modes of biological existence, on the level of organic functioning and impulsive behavior, man has attempted to live in a world of his own creation. To do so it has been necessary not only to forego life on a biological level, but also to create the assumptions and the concepts upon which he could build this human world.

At this late date in man's history it is impossible to speak with any surety about his early days, so that at best we can but hazard some surmise and suggest a few clues to an understanding of that past. Perhaps the most fruitful interpretation we can offer is to realize that from the beginning man has faced certain persistent tasks of life, namely:

1. To come to terms with nature in order to gain sustenance, to find security, and to achieve survival in a world both precarious and problematic.
2. To organize a group life so that individuals can live together and participate in the division of labor, which group living both necessitates and makes possible.
3. To transform organic functioning and impulsive behavior into the patterned conduct of group life and of human living as distinct from biological functioning.

[1] *Cf.* Julian Huxley, *Yale Review*, n.s., 28: 473–500, spring, 1939.

This contrast between man and other species provides a clue to the understanding of what we call culture. It must be clear that if man was not to follow other species he must develop certain assumptions or beliefs about the world and himself that would not only justify but also compel him to act toward the world, toward other individuals and himself in ways that offered some solution to these persistent life tasks. Here we face one of the major difficulties in discussing such a topic because in the endeavor to formulate this unique relation of man to the world and his fellows, the most extraordinary variety of ideas and concepts has been developed. Whenever we attempt, therefore, to discuss this question we are almost inevitably betrayed by the very language we employ for that purpose. Let us briefly pause, therefore, to see if we can make this situation clearer without importing into the discussion the usual mystical and subjective implications with which this topic has for so long been burdened.

Each species has worked out a way of life by learning to deal with certain selected aspects of the environment: Thus we find in the same life zone insects, reptiles, birds and mammals finding sustenance and achieving survival, each, as it were, living in one of the many worlds which the environment provides for its selective awareness, specialized needs and differentiated capacities. These diverse but coexisting worlds are created out of the totality of nature by what each species responds to and what it ignores or disregards—by the perspective, if you please, which the environment presents to each organism.

In these terms we may conceive of man as attempting to work out his way of life by and through the specific meanings, significances and relationships which he imputes to, or imposes upon, this same environment. He is still living in nature and he is still dealing with what is called the real world, but whatever he sees, thinks, feels and does is governed by these concepts and assumptions that he makes about that world and himself. Culture, then, is the process by which man creates and maintains this peculiarly human world and mode of living, built in terms of the ideas and conceptions that he himself has created and imposed upon nature and himself. All over the earth, therefore, we find different groups of people existing in this same geographical world of nature, but living in distinct cultural worlds of their own historical creation. Each of these different cultures may be looked upon as a different solution proposed by man to the persistent life tasks, in terms of its four basic organizing conceptions, namely:

1. The nature of the universe; how it arose, or was created; how it operates; who or what makes things happen, and why.

2. Man's place in that universe; his origin, nature and destiny, his relation to the world; whether in nature or outside nature.

3. Man's relation to his group; who must be sacrificed for whom; the individual's rights, titles, duties and obligations.

4. Human nature and conduct; man's image of self and his motives; what he wants and what he should have; how he should be educated and socialized.

From these four basic conceptions derive the systems of thought and logic, the standardized patterns of feelings and sensibilities and the criteria of credibility, with which the great historical cultures have been built. All these are expressed in the religion, the philosophy, the law and the art of each cultural group.

It begins to appear then that what we call culture is a way of ordering events, of organizing experience, of giving meaning and significance to the environing world and to man himself in terms of these basic organizing conceptions. Thus whatever exists and happens in the world will be seen and interpreted in the context of the ideas, beliefs and conceptions provided by each culture as the only socially sanctioned way of believing, thinking, feeling, acting and speaking.

Just as we find in different species sensitivities or irritabilities to a given range

of stimuli or energy transformations, so that while existing in the environing world of nature they nevertheless live a restricted life in accordance with this selective awareness and the patterned responses dictated by their organic structure and functional capacities, so in the same way we may look upon man as creating his special cultural world out of the totality of nature and living strictly within the limits of its formulations and prescriptions. Again it may be emphasized that while every other species has, through the mode of organic adaptation and specialization, reached the end of the road, so to speak, man has, through culture, developed what is often as coercive and limiting as organic adaptation, but still susceptible to modification and change, whenever he can and will change his basic ideas. Thus we may emphasize that culture is this historically developed way of ordering events, of organizing experience and of regulating conduct, which man himself has constructed and placed between himself and nature. Whatever man does to gain sustenance, protection and security, and in his other dealings with his environment, will be governed by his basic conceptions; whatever tools and technology he develops will arise as implications and consequences of these conceptions and will be used only in accordance with these conceptions. Moreover, whatever regulations of his own functions and prohibitions and compulsions, that he lays upon himself and his conduct, will be dictated by his conception of the place of man in that universe, his ideas of the relation of the individual to the group and his conception of human nature and conduct. Whatever he does and whatever he refrains from doing will be expressive of an idea or belief about the world and himself. Even when he repudiates and revolts against the dictates of his culture and the requirements of his society, he still acknowledges these ideas and these beliefs because only in the terms of his culture can he see, feel, think or act.

As we see in the religion and philosophy of each cultural group, these four basic organizing conceptions are interdependent, each giving and receiving sanction and support from the other three. The specific formulations that derive from these basic conceptions are expressed in law, the arts and the innumerable other formulations through which a culture declares and maintains itself. Moreover, these basic concepts, together with the selective awareness and sensibilities that they foster, and the patterns of thought, feeling and conduct that they sanction, permeate the whole complex of language and symbols, rituals and ceremonies, institutional practices, such as contract, barter, sale, marriage, political organization, etc., through and in which the social life is organized and carried on.

Since man everywhere has found the same nature and faced the same persistent tasks of life, there is a more or less universal pattern of life to be found in all cultures, each of which, however, has utilized different concepts, different meanings and purposes within this general framework. In each culture, moreover, there is a theory of origins which tells how these basic organizing conceptions of life, this extraordinary complex of beliefs, patterns of conduct and feeling, have come from some superhuman, supernatural source and may therefore neither be questioned nor tampered with. Only recently, therefore, and then only in our own culture, have we begun to realize that culture is a historically developed effort of each group to meet the persistent tasks of life—the human creation of man himself in an attempt to order events, organize group life and regulate his conduct as an alternative to a purely biological mode of existence. It is only recently, also, that we have clearly understood that this immense cultural organization depends for its continuation and maintenance upon the acculturation of each generation of children, who must be taught these basic ideas and conceptions, this selective awareness, these sen-

sibilities, these socially approved ways of thinking, believing, acting and feeling for meeting the persistent life tasks that each generation must face. Only in so far as children learn to see the world in these terms, to accept these cultural formulations, to observe these group-sanctioned patterns of conduct and speech, only thus does a culture persist. Moreover, only in so far as each child is socialized and taught the socially approved rituals, symbols, ceremonies and patterns of conduct, will the social life continue. It is evident that what the family teaches the child will be one version of the required cultural lessons and socialization, biased by the family's predilections and warped by the parental feelings about those lessons and toward the child. Moreover, the child will learn from those lessons only what they mean to him and always in accordance with the feelings aroused by the parents and their requirements. The great diversity of individual conduct, beliefs and feelings therefore become explicable in the light of this process that creates the idiomatic individual and his unique personality. We must continually remind ourselves that there is nothing in the natural, biological situation which requires or necessitates any particular culture or social organization. Nature, as it were, has been patient of the amazing variety of cultural formulations and social organizations which all over the world man has laid upon nature and himself.

The ancient belief that culture and society are super-organic, superhuman organizations, operating through large-scale, cosmic forces, like gravitation, wholly above and beyond human direction and control, becomes increasingly incredible, as we are beginning to recognize culture and society as the answers proposed by man himself to the same persistent life problems. If and when we do recognize the human origin of culture and of society and understand them as attempts to order events, to organize experience and to regulate conduct, then we can understand more clearly what the activity we call science means to our culture.

As suggested earlier, each culture is built upon the four basic organizing conceptions through which each group has attempted to give meaning and significance and order to its life, namely:

1. The nature of the universe; how it arose, or was created; how it operates; who or what makes things happen, and why.
2. Man's place in that universe; his origin, nature, and destiny, his relation to the world; whether in nature or outside nature.
3. Man's relation to his group; who must be sacrificed for whom; the individual's rights, titles, duties and obligations.
4. Human nature and conduct; man's image of self and his motives; what he wants and what he should have; how he should be educated and socialized.

In these conceptual formulations therefore are expressed whatever knowledge and understanding man has about the world and himself, organized and interpreted by reflective thinking, creative imagination and the aspirations and sensibilities cherished by the group. We may, therefore, say advisedly that each culture is an expression of the knowledge and beliefs that were available during the period of its creation and formulation. In every other culture but ours, once these formulations had been achieved and translated into a living and continuing society, they have become final and unquestionable, and the major efforts of the leaders of each group are directed to preserving and strengthening the continuity of their traditions and the full force of their sanctions. This almost universal preoccupation with the maintenance of the cultural traditions against any doubt, skepticism or change becomes explicable when we realize that the whole structure of a culture and of the social life of the group rests upon the affirmation and acceptance of certain ideas, beliefs and concepts. If man is to have any order in his group life and any meaning and design in his personal living he must make such affirmations and

perpetuate them through inculcation in his children. Thus in every group, so-called primitive or so-called civilized, there is this unformulated but intense conviction that the children must be instructed in the group-sanctioned ideas, beliefs and patterns of conduct and forced, often by terror and brutality, to accept and conform.

Western European culture is unique in that it has developed, and to-day is now institutionalizing, what might be called the "technique of habit breaking," that is, a systematic, critical examination of every idea, conception and belief about the universe and its operation, about man's origin and place in that universe, and every time-honored, traditional pattern of social life and individual conduct.

Seen in this context, therefore, what we call science may be interpreted as the most recent of man's cultural inventions. Not content with having built up a cultural world and thereby giving human life the orientation and direction that has made man a unique species, we now see that same human impulse directing man toward a continuous, critical examination of his culture in the attempt to escape that same crystallization and fixation in his culture as in his biological evolution. If we can see science in these terms, we will see it not as some special, outside force or agency, but as a part of Western European culture, a further development and refinement of the creative activities which led man to create his culture in the attempt to order events and organize experience.

If, however, we are to understand the present situation in Western European culture and the occasion for discussions such as these, we must look back and see how the four basic organizing conceptions of our culture were developed through a long, historical process of many converging streams, coming from the major cultural groups around the Mediterranean Basin, chiefly Egyptian, Chaldean, Assyrian, Hebraic, Greek, Roman and Arabic, and later the northern European groups. Slowly there was evolved out of these many cultural streams and influences a more or less unified body of ideas and beliefs and conceptual formulations expressive of the best knowledge and understanding then available. Within the past four or five hundred years this traditional Western European culture has been under critical scrutiny; beginning with Galilei and with Copernicus, Kepler and Newton, the basic organizing conceptions of Western European culture have been rendered increasingly untenable and incredible. First astronomy made obsolete the historical conception of a geocentric universe of limited spatial dimensions and temporal duration. The classic conception of the order of events and the relationships among natural processes became increasingly unacceptable as physics, and later chemistry, brought new understandings and concepts. More recently we have seen how geology and paleontology have necessitated a further revision of our basic conceptions of the world and of man, have enormously increased our time perspectives[2] and brought a new conception of man's place in the universe and his relation to nature. Within our own generation biology and anthropology and historical research have led to further revisions of our traditional beliefs about the nature of man, his relationships to group life and his social, economic and political theories and organizations. To-day, biology, psychology and psychiatry are bringing a new conception and understanding of human nature and conduct, the implications of which are so far-reaching that we can scarcely grasp their significance.

The critical situation in which we find ourselves to-day may therefore be described in these terms. Western European culture, like all other cultures, is a historical creation in terms of certain basic organizing conceptions which express the best knowledge, understanding,

[2] *Cf.* the writer's paper, "Time Perspectives," *Journal of Social Philosophy*, 4: 4, 293–312, July, 1939.

sensibilities and aspirations at the time of its formative period. Within the framework of these concepts and the culture to which they gave rise, Western European peoples have faced the persistent tasks of life, of ordering events, organizing their experience and regulating their conduct, achieving what is writ large in their historically developed societies. This same culture has given rise to the dominant character structure and has fostered the personalities, the bearers of which are the active agents in the social, economic, political and international affairs, and so are responsible for the persistent disorder, conflicts and destruction recorded by that history.[3]

For several centuries these basic concepts and beliefs of Western European culture have been losing their validity and their credibility. Just as we have seen how other cultures have disintegrated, with increasing social disorder and individual demoralization, under the impact of European ideas, techniques, and teachings, so we are beginning to realize that our own culture has been cumulatively undermined by what we call scientific investigation, so that we no longer can accept or believe the older ideas and concepts. This process of disintegration has not been uniform, so that we find not only different groups of people, but also single individuals reflecting these changes in different areas and to different degrees. Thus some sections of the population have been relatively untouched by any new ideas and so they continue to live in terms of the traditional formulations untroubled by any doubts or anxieties over the crucial aspects of life. Other sections of the population only partially accepting new ideas are attempting to live in terms of the old and the new, facing increasing difficulty and strain while trying to reconcile the growing incongruities and discrepancies in their lives.

[3] *Cf.* the writer's paper, "Cultural Coercion and Individual Distortion," *Psychiatry*, 2: 1, 11–27, February, 1939.

If time permitted, it would be interesting to examine some of these ever-widening chasms in our individual and group lives, as, for example, our demand for modern medicine while we continue to reject man's mammalian ancestry which gives modern medicine its validity. Likewise we might reflect upon the difficulty of administering the law upon assumptions about the cosmos and human nature that are becoming progressively obsolete and absurd. But such an inquiry would lead into every aspect and phase of society and individual living, where we see increasing disorder, conflicts and confusion as we face the persistent tasks of life for which our culture no longer provides guiding concepts and patterns and sanctions. From this cultural view-point, the bewildering array of social problems, of internal and of international chaos and conflict, as well as the mounting anxiety and insecurity in our personal lives, appear as symptoms of the breakdown of the older Western European culture.

In the midst of these alarms and conflicts, the question of what men of scientific persuasion can do becomes one of the crucial issues of our time. The task of rebuilding our culture, of constructing a new framework of concepts and beliefs to give order, meaning and significance to life becomes ever more insistent. But, it must be clearly recognized, this is essentially an artistic task, of creating a consistent picture of the universe and of man that will not only satisfy our new criteria of credibility, but also express the new aspirations and sensibilities through which we seek to attain the enduring human values. More concretely, we must courageously and imaginatively create the four basic organizing conceptions essential to culture—the nature of the universe, man's place therein, his relations to his fellows and his society, and human nature and conduct—utilizing our recent scientific knowledge and understanding for that purpose, just as our predecessors utilized the best contem-

porary knowledge and understandings available to them for constructing the culture they bequeathed to us.[4]

The more clearly we realize the stupendous achievements of the past in building up Western European culture and sincerely recognize our indebtedness to those great leaders who created this amazing structure of ideas and beliefs and aspirations, the greater are our obligation and responsibility to do for our time what they did for their age. This is the very ideal of scientific endeavor, to carry forward the task of ordering events, of reorganizing our ideas and procedures, in our never-ending pursuit of understanding the world and all it contains, including man and his culture.

Until we formulate the *meaning*[5] of modern science for these essential concepts and beliefs, we must continue to live anxiously and contingently, unable to achieve any order in our society or our personal lives, because we lack this unified set of concepts through which alone we can order events, organize experience, regulate conduct and find dimensions for our values and aspirations. To find the courage and faith for such a gigantic task, amidst the chaos that now threatens, we shall have to remind ourselves and our children that, however dark and threatening the future, man can now imaginatively project ahead a culture dedicated to the conservation of those human values that for long he has vainly sought.[6]

In the years to come it is probable that this discovery of the human origin and development of culture will be recognized as the greatest of all discoveries, since heretofore man has been helpless before these cultural and social formulations which generation after generation have perpetuated the same frustration and defeat of human values and aspirations. So long as he believed this was necessary and inevitable, he could but accept this lot with resignation. Now man is beginning to realize that his culture and social organization are not unchanging cosmic processes, but are human creations which may be altered. For those who cherish the democratic faith this discovery means that they can, and must undertake a continuing assay of our culture and our society in terms of its consequences for human life and human values. This is the historic origin and purpose of human culture, to create a human way of life. To our age falls the responsibility of utilizing the amazing new resources of science to meet these cultural tasks, to continue the great human tradition of man taking charge of his own destiny.

[4] *Cf.* John Dewey, "Theory of Valuation," International Encyclopedia of Unified Science. Volume II, No. 4, 1939, University of Chicago Press, page 66: "The chief *practical* problem with which the present *Encyclopedia* is concerned, the unification of science, may justly be said to center here, for at the present time the widest gap in knowledge is that which exists between humanistic and non-humanistic subjects. The breach will disappear, the gap be filled, and science be manifest as an operating unity in fact and not merely in idea when the conclusions of impersonal non-humanistic science are employed in guiding the course of distinctively human behavior, that, namely, which is influenced by emotion and desire in the framing of means and ends; for desire, having ends-in-view, and hence involving valuations, is the characteristic that marks off human from non-human behavior. On the other side, the science that is put to distinctively human use is that in which warranted ideas about the non-human world are integrated with emotion as human traits. In this integration not only is science itself a value (since it is the expression and the fulfillment of a special human desire and interest) but it is the supreme means of the valid determination of all valuations in all aspects of human and social life."

[5] *Cf.* the writer's paper, "General Education," *Social Frontier*, March–April, 1937. It must be emphasized that we need more than abstract scientific laws, generalizations, quantitative findings and formulas; we are waiting for a statement of the *meaning* of scientific knowledge in terms of its emotional significance for living, so that modern astronomy, geology and biology will provide the equivalent of "Now I lay me down to sleep," in which the traditional cosmology, biology and psychology were expressed.

[6] *Cf.* Ortega y Gasset, "The Modern Theme," New York, Norton, 1933.

A SERPENT-SEEKING SAFARI IN EQUATORIA

I. UGANDA

By ARTHUR LOVERIDGE

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THREE liners lay alongside Kilindini wharf disgorging their human freight into the vast customs' shed, where mountains of baggage already awaited the attention of two harassed Kenya officials. A small group of importuning arrivals tagged after the tired two each time they moved. A babel of voices, chiefly Swahili, rose to such a crescendo at times that it was necessary to shout even when addressing persons close by. Despite the wharves, cranes, sheds and obvious attempts at organization, Kilindini remains, in essentials, much the same as twenty-five years ago. Naturally we were glad to escape from the orgy and retreat to the steamship *Llandovery Castle* for lunch before the second ordeal of entraining for the long journey up-country.

The expedition may be said to have commenced when we were roused at 11:30 P.M. in a London hotel by a telegram which read something like this: "As possibility *Llandovery Castle* may be rerouted by West Coast, sailing in twelve hours, do you wish to cancel reservations?" for this was September and at the peak of the Munich crisis. Since we certainly did not propose to alter our arrangements, the next afternoon found us in the ship's lounge listening to a dissertation on what to do in the event of an attack by machine-gunning planes, by bombers, by submarines or a combination of all three! In the raw greyness of that late September evening the sight of destroyers patrolling the turgid waters off Dover gave confidence.

Well, here we were at Mombasa at last with glorious months of open-air life ahead of us, during which weeks at a time would slip by without our hearing any news of troubled Europe. The purpose of my visit* was to investigate the fauna of various patches of forest. Some of these had already suffered pitifully at the hands of man so that the animal life which had flourished there in bygone days was depleted or had disappeared. Other forests proved almost virgin, and served as a check on conclusions drawn from those where destruction by fire and axe had already affected the fauna.

Our first destination was the Mabira Forest, which covers some 120 square miles. A rubber concession in this forest was under the management of the well-known Uganda planter, Mr. J. L. Jarvis, who not only placed an empty house at our disposal, but had the encroaching tangle of vegetation surrounding it cleared away, and generously drove us to it from Jinja. As we neared our destination he ran over a large example of the commonest of African blind snakes. Jarvis pulled up while I ran back to pick up the poor creature. Strangely enough, not another of the species was encountered until my cook found one at my last camp on Magrotto Mountain, near Tanga, nearly 900 miles away.

We had scarcely settled in when a black snake with narrow white crossbands was found by the table boy on his way from kitchen to table. This venomous garter snake (*Elapsoidea*), a relative of the cobras, was extremely common on Magrotto, but not met with elsewhere during eight months of persistent collecting!

* As a Fellow of the John Simon Guggenheim Foundation.

THE COOK AND SKINNERS, FORMING THE EXPEDITION'S NATIVE PERSONNEL
FIVE JERSEYS WERE BOUGHT ON THE OUTWARD VOYAGE AND ALL LETTERS EXCEPT ONE, PICKED OUT OF EACH. U.C.M.S.CO. SIGNIFIED UNION CASTLE MAIL STEAMSHIP CO. THE COOK, BLAZIO, IS STANDING AT THE RIGHT, WHILE THE SKINNERS, KIZAMBA (LEFT) AND ALI (RIGHT), ARE SEATED.

Collecting is truly full of surprises. Coming to a clearing in the forest where a native had a small plantation of coffee trees, I hailed the owner with the news that any snakes which he brought to my camp could be transmuted into cash at the rate of 30¢ (8 cents U. S.) each. "I saw one only a few minutes ago which you can have," said he, and walking to a coffee tree in the last row adjoining the forest, pointed out a young boomslang. Though the large-eyed, chunky-headed youngster belonged to one of the commonest African species, we never saw nor collected another during the course of the *safari,* despite the fact that about 650 snakes of 71 species were preserved! Here in the Mabira Forest we also took two snakes, one of which was entirely new to Uganda, while the other furnished a furthest east record of the black-and-red snake (*Bothrophthalmus*), common in Liberia and the Cameroons.

Best of all our animal acquisitions at Mabira was a live tree pangolin which reaches the limit of its eastward range in Mabira. This queer, long-snouted, viscous-tongued termite-eater is covered with large scale-like plates. When disturbed it curls up, presenting its armorplating to the world, and is consequently often mistaken for an armadillo by Europeans on the rare occasions on which they have the good fortune to see one.

One day a babel of hoarse cries and the tinkling of bells, as two curs ran hither and thither through the scrub fringing the forest, advertised the fact that a buck hunt was in progress. All afternoon the uproar waxed and waned as the persistent huntsmen searched the

scrub. After sunset we saw the party returning with a little buck of a race of the blue-grey forest duiker. I bought it for a shilling, and after I had taken its measurements one of my skinners got to work on it. But Kizamba, the young huntsman who had brought the animal onto the veranda, growing impatient at Ali's slow and careful skinning, began to help. I noticed his skilful, quick manipulations, so when he said, "I like this work, I'd like to work for you," I agreed immediately.

Thus it came about that Kizamba remained with me for the whole trip and proved to be the most fearless and nimble catcher of rats and lizards. To see him poised, half-crouching, bright eyes intently fixed on some hole that was being excavated by a companion, was sheer delight. When the occupant of the hole dashed out it was rarely that it escaped, for Kizamba would pounce upon it with a flat palm and seize it by the neck. "Kizamba *sawasawa paka*" (Kizamba is just like a cat), Yolan had remarked on one of these occasions, much to the amusement of all concerned. Every now and then the razor-sharp teeth of some hapless rodent would be buried in a finger. Kizamba might wince as the iodine was being applied, but was never deterred by such incidents. He was a born hunter and as we crept through forest undergrowth in pursuit of wary crested guinea-fowls, he would pause on one foot, the other upraised, looking for all the world like a human pointer or setter. As a skinner he was less skilful than Ali, but when he could be spared to accompany me I knew that the trip would be more fruitful, for many a time his sharp eyes detected some slight movement that I had failed to notice.

THE NATIVE-DRIVEN TRUCK STARTING FOR BUDONGO WITH FIVE MEN AND A TON OF EQUIPMENT, SELECTED A SOFT SPOT IN MABIRA'S RUBBER PLANTATION.

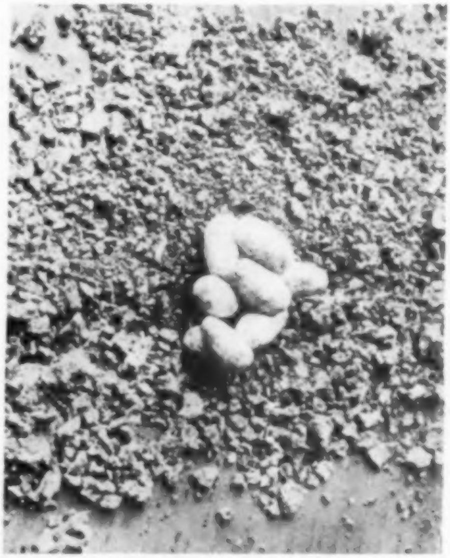
We left Mabira by lorry for the Budongo Forest, not far from Butiaba on

the northeastern shores of Lake Albert. Here we pitched our tents in a forest-nursery beside the Buchanan Sawmills, where 300 natives were employed. This site offered the advantage of a road cut into the heart of the forest, but as we were to discover later, the terrifying noise, both by day and night, made by caterpillar tractors drawing logging trains, had scared the creatures of the wilds further afield.

Snakes of course were unaffected and at first the prospects were promising, for on the very afternoon of our arrival an interesting tree-snake fell on a party of natives who were engaged in shifting balks of timber right in front of our tent. A big black-and-white cobra was brought in by a tree-felling gang at the end of the day. However, not another serpent did these men bring in during the remaining fortnight; possibly, in comparison with their good wages, they thought the 30 cents (East African) per snake too paltry.

Next day our "boy" Zachio, engaged in setting the table, was bringing something from the kitchen (a fire in the open) when he jumped, yelled "snakes" and made a dash for the tent. Snatching up my snake-stick, I ran back along the narrow path, freshly made through a luxuriant growth of vegetation. Thirty feet from our tent I caught sight of two velvety-green night adders, which had been scared into the grass by Zachio's appearance and were now returning. The anterior third of each was raised high, and so flattened that for a second I thought they were young cobras. They were almost intertwined, their lower portions so close together that I pinned both down with my T-ended stick. At this one reptile began to savagely bite the other's neck, enabling me to seize both together with the forceps. In this way I carried them back to the lethal tin in which some hundreds of snakes were destined to pass

NATIVE PATH IN MABIRA FOREST
OWING TO DENSITY OF UNDERGROWTH IN UGANDA FORESTS, COLLECTING WAS LARGELY RESTRICTED TO THE VICINITY OF SUCH PATHS.



SNAKE'S EGGS FROM LAKE MUTANDA
HUNDREDS OF EGGS OF MANY SPECIES OF SNAKES WERE BROUGHT TO CAMP. THOSE OF THE RARER KINDS WERE CARRIED TO THE CONGO, WHERE THEY HATCHED.

A LONG-SNOUTED, VISCOUS-TONGUED TERMITE-EATER
THIS STRONGLY-CLAWED CREATURE CURLS WITHIN ITS SCALE-LIKE DEFENSIVE ARMOR AFTER THE MANNER OF AN ARMADILLO.

their last moments. "A courtship performance," thought I, but subsequently, on examining the two beautiful creatures, found both were males; so it was nothing but a fight after all—the flattened necks an attempt at intimidation!

Three days later an Indian arrived on a cycle to say that there was a big snake, thicker than his arm, near his house. I ran most of the quarter-mile there and found three Indians, armed with poles, surrounding a patch of grass in the middle of the path where two ways met. The snake, they said, was in this. In vain I scrutinized the spot, expecting a python, until one of my boys pointed out the great flat head of a Gaboon viper within two feet of me. The five-inch wide head looked like one of the many leaves scattered about, the rest of the reptile was entirely concealed by the grass. So torpid was its behavior that it never moved when I planted my stick upon its nape, nor when I picked it up in my hand; neither did it attempt to strike when I transferred it to a bag in which to transport it back to camp. The bulky creature, though measuring only fifty-one inches, weighed eight pounds. Another of these vipers, taken on Magrotto Mountain eight months later, was two inches longer yet weighed eleven pounds, for she held forty-three eggs.

In December we left Budongo Forest and drove southwards through Fort Portal—where a native brought us one of those ridiculous, elongated, snake-like lizards (*Chamaesaura*) whose hind limbs are reduced to little flaps, with or without minute digits—thence to Kibale Forest. A road had been cut recently through the southern portion of this great forest, but we had to make camp two miles in where an unbridged stream barred further progress to cars. It was successfully bridged by a labor gang

SEEKING CAMP SITE, IN BUDONGO FOREST OF NORTHWESTERN UGANDA
FOR AN HOUR WE TOURED THE FRINGE OF THIS MIGHTY FOREST SEARCHING FOR A CAMPING SITE

under native foremen just before we left; meanwhile we crossed it daily on a tree-trunk and gained access to several more miles through virgin forest.

Kibale will be remembered principally by the wonderful profusion of its gorgeous butterflies and the abundance and tameness of its monkey-folk. Several of the trees beside our tents bore fruit beloved by the simians and proved such an attraction that we counted no less than six species within a hundred yards during our ten-day stay. The only timid ones were the beautiful black and white colobus; huge bands of the rufous-capped colobus roamed these woods and greeted a shot with a terrific outburst of menacing cries and grunts. Then there were the mangabeys whose black faces and blackish-brown hair make them the Negroes of monkeyland. Nor shall I forget a bold little Schmidt's monkey which descended a slender branch already borne down by a heavy green fruit the size and shape of a cannonball. The monkey gnawed at the coveted fruit on which it sat, while momentarily one expected the slender stem from which it hung to give way under the additional strain. In addition to the six species seen, we often heard the raucous cries of chimpanzees reverberating through the forest.

As a corollary to the presence of so many monkeys there were thousands of flies, worse still, a disgusting parasite which assailed the nostrils of our native staff. Fortunately Blazio, our cook, was acquainted with the correct technique for their removal. A needle and thread were passed through a fine, stiff, yet hollow, grass stem, then back again so as to leave a loop at one end. The noose and grass were then passed up the nose and after a little angling the maggot would be snared and jerked from its hold; sometimes a good deal of bleeding accompanied the operation.

IN THE SECLUSION OF OUR CAMP IN THE BUDONGO FOREST
FINALLY WE FOUND SPACE FOR THREE TENTS AMONG YOUNG MAHOGANY TREES AT THE FOREST EDGE. THE DRYING CAGE FOR BIRD SKINS IS IN FOREGROUND.

LOGGING MAHOGANY FOR THE BUCHANAN SAW MILLS
THE CLEARING FOR THIS TRAMWAY, RUNNING FOR MILES INTO THE HEART OF THE FOREST, PROVIDED A GOOD MEANS OF REACHING THE FOREST DENIZENS.

One day as I was hunting in this forest I came upon the first *living* black-striped tree-snake (*Hapsidophrys*) that I had yet met. The beautiful and harmless velvety-green reptile was on a level with my face as I pushed through the bushes, for it was gracefully entwined about a spray of evergreen. It made no attempt to bite when lifted down, nor subsequently under considerable provocation during the tedious process of posing it for its portrait, the sense of which it could not comprehend!

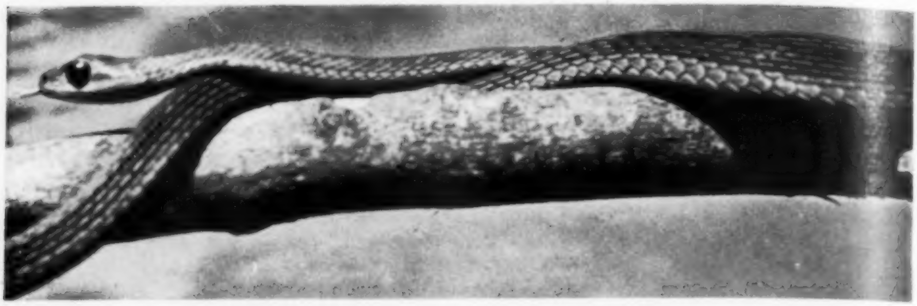
From Kibale we departed for Bundibugyo at the northwestern foot of the Ruwenzori Range, by a mountainous escarpment road that had only just been completed. The scenery, chiefly by reason of its stupendous scale, was magnificent. Frequently we crawled round some corner, the rock-hewn cliff towering above us on one side, while on the other it fell abruptly away to a grass-grown gorge a thousand feet below.

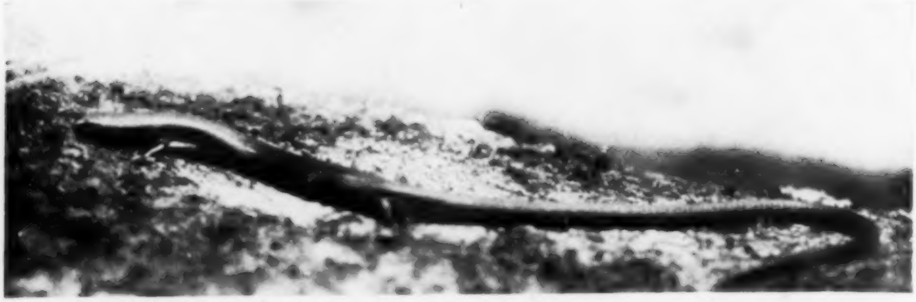
A few years before, Captain Pitman, who has done so much to advance our knowledge of Uganda snakes, added two species, obtained in Mabira, to the Uganda list. Another example of one of these reptiles, an arboreal spitting cobra (*Naja goldii*), was brought in by two Bwamba natives at Bundibugyo; since it measured 7 feet 1 inch in length it is probably the longest of its kind taken anywhere, as well as the second known Uganda record. Here also we got the second example of the other tree snake (*Boiga pulverulenta*).

The lorry which was to come from Fort Portal to take us three quarters of the way round Ruwenzori was several hours late. As we climbed back up the

HUNTING A COBRA AT BUDONGO WITH NATIVE ASSISTANCE

THE REPTILE HAD BEEN SEEN CROSSING A PATH WITH A LARGE RAT IN ITS MOUTH. IT SOUGHT REFUGE BENEATH THE LOG.





AN ARBOREAL SNAKE FROM KIBALE FOREST AND A FOUR-TOED SKINK

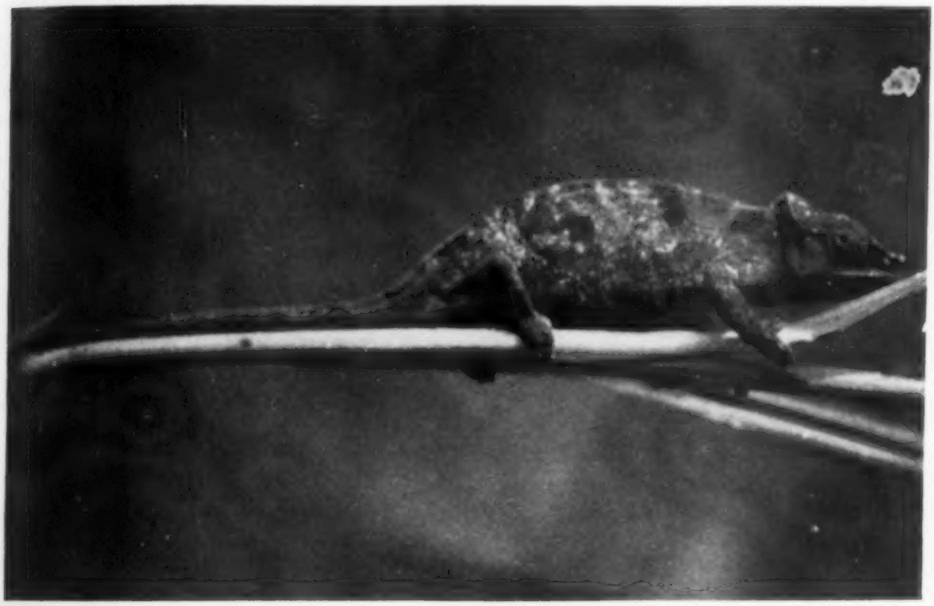
THE BEAUTIFUL GREEN SNAKE ABOVE WITH TEN BLACK LINES ALONG ITS BACK, FORMS AN INTERESTING PARALLEL TO THE ROUGH GREEN SNAKE OF OUR SOUTHERN STATES. THE BURROWING LIZARD BELOW, KNOWN ONLY FROM THE RUWENZORI RANGE, WAS DISCOVERED IN 1905. NO SECOND EXAMPLE OF THE TYPICAL FORM WAS FOUND UNTIL THE PRESENT TIME WHEN MANY, TOGETHER WITH THEIR EGGS, WERE COLLECTED.

JOHNSTON'S CHAMELEON FROM MUBUKU VALLEY

THE MALE CHAMELEONS ARE HORNED. WE HAVE SEEN THEM USE THEIR WEAPONS TO PROD EACH OTHER WHEN A SHRUB WAS TOO SMALL TO SUPPORT TWO OF THESE BEAUTIFUL CREATURES.

terrific escarpment road we developed engine trouble, which resulted in so many delays that the sun was setting by the time we reached the rest camp at Bugoye, where a cold wind was whistling down the valleys from the glaciers above, the latter hidden by intervening ridges. In fact, one might camp at Bugoye in complete ignorance of the proximity of a 16,800 foot mountain.

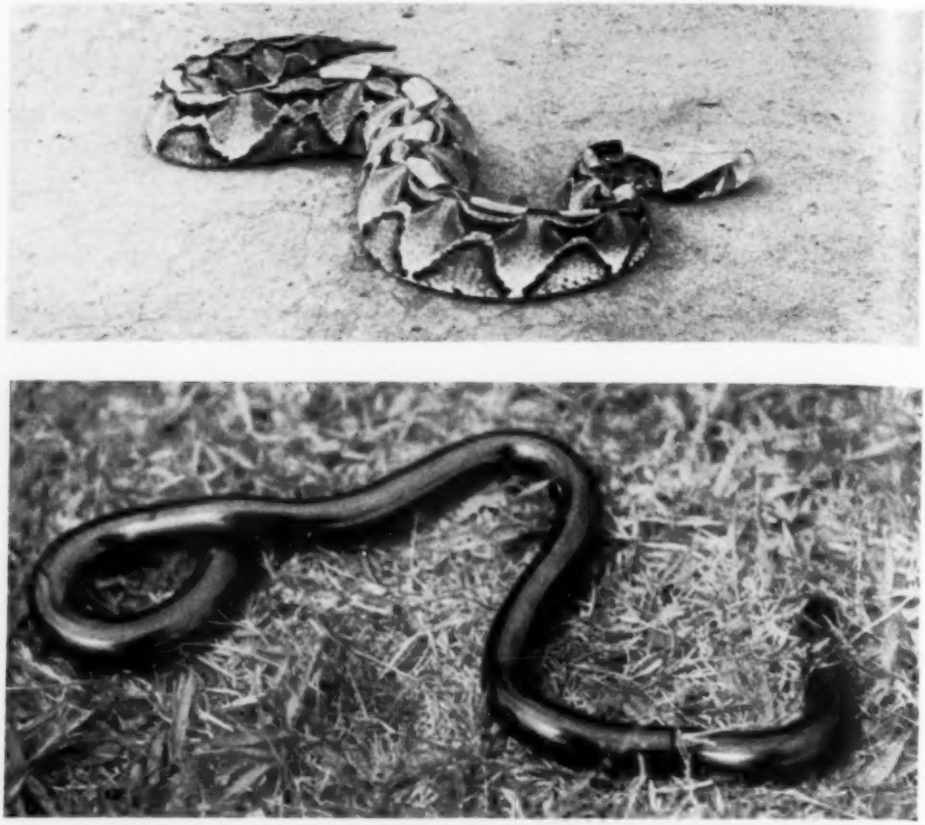
Three men had been sent ahead to cut a path through the tangle of vegetation. We found their work pretty sketchy in places, but the task was a tremendous one. Up and up we toiled in the midday heat, sun smiting upon bent backs. From Bugoye to the campe-site beneath the great fig tree on Mihunga ridge is said to be a four-hour climb. I managed to do it without a load, but the porters took from six to eight hours. Later I discovered a much easier route and one which takes little cutting, *viz.*, through a swamp at the very foot of Mihunga, thence straight up the hogback to the fig tree instead of following the horse-shoe-shaped ridge around the head of the valley. This is the track taken by many natives; when asked, however, why they had guided us the longer way, they replied that it was the custom, for all expeditions had taken that route! From fig-tree ridge we had magnificent views of the snowy peaks, indescribably beautiful when tinged by the rosy glow of sunset.



THE FEMALE OF A RARE SPECIES OF RUWENZORI CHAMELEON

THE FIRST PHOTOGRAPH OF THE HORNLESS FEMALE OF A SPECIES HERETEFORE UNREPRESENTED IN ANY AMERICAN MUSEUM. THE CREATURE IS RARE BECAUSE IT DWELLS IN THE FOREST CANOPY.

Next day we dropped down into the Mubuku Valley, slopped our way through a swamp, then recommenced the tedious ascent of the valley. I pushed on to select a camping site; on through the forest out into the grassland beyond, always urged onward and upward by our guide, who recommended some site "just a little farther on." Eventually I protested that I was sure that the forest through which we had passed would prove more suitable for my investigations



A MARKED GABOON VIPER AND A SLEEK BLIND SNAKE

THE SLUGGISH FIFTY-ONE INCH SNAKE ABOVE, FROM THE BUDONGO, WAS FOUND BY AN INDIAN CONCEALED IN A PATCH OF GRASS IN THE MIDDLE OF A PATH. THE SNAKE BELOW WAS FOUND BENEATH STONES. AN ARDUOUS SAFARI WAS MADE OVER THE MOUNTAINS FOR THE SOLE PURPOSE OF OBTAINING SPECIMENS OF THIS PARTICULAR REPTILE.

than any we were likely to encounter at higher altitudes. So, turning about, we retraced our steps for a mile or more, skidding and slipping on the steep slope as we descended.

It was necessary to clear a site among the trees by removing the dense growth of shoulder-high ferns. During this lengthy business I captured three of the little lizards (*Lygosoma m. meleagris*) which we had come to look for. None of these four-toed skinks had been taken since the discovery of a single specimen in this very valley by the British Museum Expedition of 1905; so during the following days we sought to learn all that we could about their secretive habits, found their eggs, watched the young hatching and secured a series of fifty adults.

Another desideratum was a strange, one-horned chameleon which dwells in the forest canopy and consequently seemed likely to defeat all our efforts to secure it. Only half-a-dozen specimens are known. The three-horned species, named after its discoverer, Sir Harry Johnston, I found and captured, but day succeeded day without news of the other. Then one morning on returning

AN ANGRY SNAKE POISED TO STRIKE AND A VELVETY GREEN TREE VIPER

THOUGH ONLY AN OPISTHOGLYPH, THE REPTILE ABOVE STRIKES SO SAVAGELY AND FLATTENS ITS HEAD SO EFFECTIVELY THAT ONE ACCORDS IT THE DEFERENCE DUE A MORE DANGEROUS SNAKE. THE VIPER BELOW WAS ONE OF SEVERAL FOUND BASKING ON TOP OF SEDGES IN A SWAMP.

to camp I was met with the tidings that Zachio had found a dying chameleon lying on some branches piled at the edge of our clearing, not a dozen feet from my tent. Sure enough, it was the beautiful bluish-green, yellowish and purplish-brown *xenorhinus*. Later we secured an example of the hornless female.

In our search for skinks we came across some eggs which I recognized as belonging to a certain group of geckos (*Cnemaspis*). Once on the trail we found quite a number of the eggs, but the geckos which had laid them were living high up in the mighty forest trees. Night after night, when dinner was finished, I took a flashlight and searched the trees about whose roots we had found eggs in the hope of intercepting some female descending to lay. It was all to no avail. We even felled dead trees and, dissecting them piecemeal, subjected every part to minute examination. Then on the very day before we were due to leave, Kizamba returned from a daybreak inspection of the most promising tree with a fine adult female which he had captured on the edge of a fissure in the bark! Probably it represents an undescribed race, for no member of the genus is known from the Ruwenzori Range.

We had few regrets on leaving the

NATIVES INSPECTING CORMORANTS' NESTS ON MUTANDA

AS WE WERE BEING PADDLED BACK TO CAMP ONE MORNING, MANY CORMORANTS WERE SEEN TO LEAVE SOME TREES, GROWING FROM THE CLIFF OF AN ISLET IN THE LAKE. INVESTIGATION OF THE NESTS REVEALED THAT THE YOUNG HAD FLOWN.

Mubuku camp, for the climate had been atrocious. Fine at daybreak, it soon clouded over, growing darker and darker till noon, when it was sometimes necessary to light the lamps if one wished to read or write. Then rain would fall in torrents, downpour succeeding downpour till late afternoon. So, having spent eleven days at Mubuku camp, we packed our belongings and made a forced march past fig-tree ridge to a lower spot at Mihunga where the British Museum party had stayed on their pioneering zoological trip in 1905.

Here, below the forest belt, the sun shone gloriously and rodents existed in incredible numbers and variety. Day after day our traps furnished some new topotype of rat or pigmy mouse first found by Woosnam and his colleagues. We recovered pigmy mice from the stomachs of a mamba and a tree viper brought in by natives. A tree viper, named *Atheris woosnami*, was brought in and I was anxious to secure a series for study. I engaged a couple of men for several afternoons from 4 till 6 P.M. to systematically cut the ten-foot elephant grass, sedge and bush in a swamp where elephants had made a path in quest of wild bananas. This not only resulted in my capturing some of the beautiful green vipers, but also several other kinds of reptiles and amphibians whose presence had been unsuspected, though we had been camping in the vicinity for a fortnight.

One afternoon a chimpanzee climbed a lone tree on a knoll 200 yards away and watched the frog-hunting intently. Hav-

ANXIOUS BOATMEN WITH DUGOUTS FOR HIRE ON LAKE MUTANDA

ON THE MORNING OF OUR DEPARTURE SEVERAL OPTIMISTIC BOATMEN BROUGHT THEIR CLUMSY CRAFT TO TAKE US TO THE SOUTH END OF THE LAKE, A JOURNEY WHICH TOOK SEVERAL HOURS.

ing reached his own conclusions about our mentality, he clambered slowly down and departed with dignity. Since I had found a number of chimpanzee beds, or platforms, constructed in high trees within a mile of this swamp, seeing the creature at Mihunga was not altogether a surprise, though, according to native reports, they only pass from one forest to another.

Our stay on Ruwenzori had been most successful, so it was with light hearts that we returned to Bugoye to pack the collections and rearrange the loads for a fresh advance.

On our arrival above Lake Bunyonyi, pitching tents seemed unnecessary, for there was a good thatched tent-shelter in addition to the gloomy and grimy little rest-house, which we avoided. Since we were all very tired after a long day we thankfully had the loads moved in, building a low wall of boxes and tentage across the front of the shelter. Darkness fell before we were settled in, and we were glad of our overcoats during dinner, for there was a piercing wind. As we snuggled beneath the blankets of our beds little did we imagine that our awakening would be to the most miserable situation experienced during the whole safari.

Our shelter, at an altitude of about 7,000 feet, faced and lay but fifty feet back from the brink of a thousand foot bluff above the lake. By midnight a strong wind was carrying an endless succession of vaporous clouds over this scarp and straight into our retreat, where they condensed rapidly upon the cobweb-covered grasses on the thatch and dripped upon our nets. When daybreak came

we found that the foot of every bed was soaking, for the moisture—condensing on the mesh of the mosquito nets—had trickled slowly down till absorbed by the bedding. Clothes hung up the night before were sodden. Nor was this all, for many grime-laden cobwebs when overburdened with moisture had collapsed as black blobs on nets, tables and chairs. As if our misery were incomplete, a bleak breeze continued to blow wisps of vapor about us.

After a week at Nyakabande, an exhausting climb over the mountains from there brought us to Mushungero, a rest-camp situated at the end of a little peninsula on the eastern shores of beautiful Lake Mutanda. This was a truly lovely spot where the sunrises and sunsets, the papyrus-covered islets and the background of purple mountains went to form a picture not readily forgotten. Mushungero was the home of an undescribed snake first found by Captain C. R. S. Pitman; we secured a series in a short time. An intelligent native, who had collected for Captain Pitman, appeared each evening with a large basket, in the bottom of which were snakes, alive and uninjured, representing his day's catch. In addition, he brought several hundred eggs from half a dozen different species of snakes, though the majority were those of a harmless, frog-eating, green kind.

The day after our arrival I went in a dugout in search of the local race of otter. As the two boatman paddled across a lily-covered bay they pointed out a duck swimming among the pads—this I shot. A few minutes later I fired at another when hey presto! up popped the enormous heads of a pair of hippopotamus not two hundred feet away. Their appearance was greeted with roars of laughter by the boatmen, who perhaps had half-expected some such sequel to the shot. Just around the corner, and within half an hour of setting out, we sighted a pair of otters swimming away. Paddling only when they dived, remaining low when they came up to breathe, we came within range and I dropped one with a bullet through his brain.

In view of the frontier precautions in Europe, it was refreshing to find the Uganda-Ruanda frontier denoted only by a signboard inviting one to drive hereafter on the right, instead of the left, side of the road. In due course we reached the small frontier village of Ruhengeri, where the customs and immigration officer was courtesy itself; he could scarcely have been more helpful in filling in the various forms, after which we were free to continue our journey to Kisenyi with a minimum of delay.

Since we had been urged not to miss the opportunity of seeing the lava flow from Mount Nyamalagira while in the vicinity, we drove out from Goma (the port on Lake Kivu adjacent to Kisenyi) one morning till we found our way barred by a high bank of solidified lava two hundred yards across. The lava, which was flowing beneath the crust, was pouring into the lake away to our left, and clouds of steam arose as the water boiled on coming in contact with the molten mass. From volcano to lake it was flowing for a distance of twenty miles, and in places was said to be on a two-mile front. A mission, native village and a coffee plantation had been overwhelmed and buried beneath the lava.

SUNLIGHT AND PLANT LIFE

By Dr. EARL S. JOHNSTON
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THERE is an important chemical reaction in green plants that has determined and continues to determine the destiny of nations and the very existence of man. This reaction takes place in light and is technically known as photosynthesis. By this process carbon dioxide and water are united in the presence of chlorophyll, the green plant pigment, to form the simple sugars. These products are elaborated into starch and other carbohydrates and into proteins, organic acids, fats and other plant synthates. Many of these compounds are food, not only for the green plants themselves, but also for animals and nongreen plants. These foods, on being assimilated, are built into new structures formed in growth and the stored energy is released.

Green plants, by this process of photosynthesis, supply the living world with food. The struggle for land rich in food resources has more than once influenced the destiny of ancient as well as modern people. Through the centuries the availability of food has determined to a large extent the size of centers of population. Transportation, to be sure, enters as an important factor, but this has been governed in general by fuel. Coal beds and oil fields are resources of potential solar energy resulting directly or indirectly from photosynthesis. Here again man, in his struggle for existence, battles by brute force or cunning for supremacy. One is tempted to continue *ad infinitum* with examples showing the relationship of solar energy acting through the green plant to innumerable chemical and physical reactions and to the destiny of man.

Solar energy received at the surface of the earth is far from being constant in value. It differs greatly from time to time with respect to its *duration*, *intensity*, and *quality*.

The length of day, or *duration* of sunlight, varies with the latitude and the season. At the Equator there are approximately 12 hours of darkness and 12 hours of light for each day throughout the entire year. The other extreme is reached at the poles, with 24 hours of light during the summer season and 24 hours of darkness during the winter season. In intermediate latitudes the hours of sunshine fall between these extremes.

The *intensity* of sunlight varies inversely as the square of the distance from the sun. Since the earth's orbit is elliptical with the sun at one focus, there is a difference of approximately 7 per cent. between the amount received when the earth is at perihelion in January and when it is at aphelion in July. Other variations in intensity are due to the presence of dust particles and water vapor in the atmosphere. An increase of 1 mm pressure in water vapor decreases the radiation intensity about 2 per cent. Intensity also varies with the angular distance of the sun from the zenith, according to season and time of day. Changes in actual amount of energy radiated from the sun also influences the intensity of solar energy reaching the earth's surface.

The *quality* or, more accurately expressed, the wave length of sunlight also

[1] On May 1, 1929, through the initiative of Secretary C. G. Abbot, the Division of Radiation and Organisms of the Smithsonian Institution was established for the purpose of undertaking "those investigations of, or directly related to, living organisms wherein radiation enters as an important factor." Throughout this period important financial aid has been given by the Research Corporation of New York.

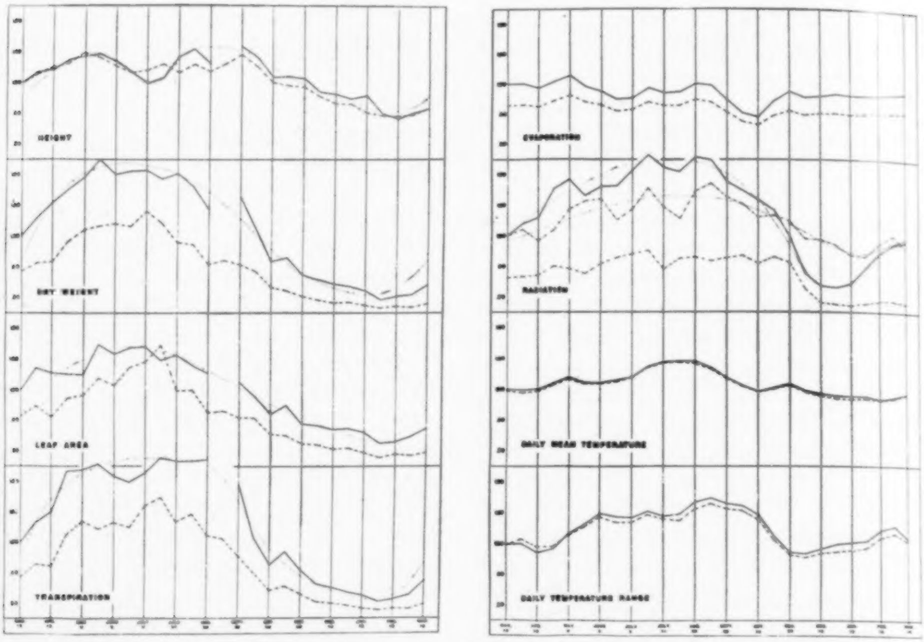


FIG. 1. RELATIONSHIPS BETWEEN SUNLIGHT AND PLANT GROWTH.
PLOTTED FROM THE FOUR-WEEK RELATIVE VALUES OBTAINED FROM BUCKWHEAT. EXPOSED SERIES: ————; SHELTERED SERIES: – – – – – –; SUNSHINE DURATION: –.–.–.–.–; SMOOTHED GRAPHS: . . . .

varies. The white light of the sun with the maximum energy in the yellow becomes richer in red as the sun drops from the zenith to the horizon. This variation in wave-length distribution is due to the lens effect of the atmosphere covering the earth and to the differential absorption of light. In the North Temperate Zone, for example, sunlight is relatively richer in blue and violet during the summer than it is in winter. This is likewise true for high altitudes.

No wonder a wide range in type of vegetation is encountered over the face of the earth. To be sure, temperature and moisture are important factors in bringing about this variation, but after all, variations in temperature and moisture are caused by variations in the solar energy reaching the earth.

As a result of observations and studies by plant ecologists and plant physiologists, many interesting relationships have been found between light and the structure and growth of plants. The brilliant colors of alpine flowers have been attributed to the presence of ultraviolet light in the clear sky of high altitudes. The broad succulent leaf growth within a dense tropical forest can be attributed in part to reduced light. Many interesting structural modifications in desert plants are brought about by changes in moisture and light. Although such observations are interesting, little quantitative data can be obtained until plants are grown under controlled conditions.

The plants around us are continuously registering within themselves the total effects of the climate, sunlight being one of the important factors of the climatic complex. Perhaps the most familiar records are those made by trees. The type of rings, their thickness and shape, give to those familiar with the language a story of the climate during the life of

the tree. The researches of Douglass (1932) on tree rings have given us a most instructive picture of the climatic conditions prevailing during the past centuries.

Use has actually been made of the plant as an integrating instrument for measuring climatic conditions. Johnston (1921) conducted an experiment in which the climatic conditions of a greenhouse for a period of 13 consecutive months were recorded by sets of "standard" buckwheat plants. The plants were grown for 4-week exposure periods. A new period began every 2 weeks. Measurements of stem height, dry weight, leaf area and transpiration were made at regular intervals. Simultaneous measurements of evaporation, radiation and temperature were also obtained. Two series of tests were conducted, one under ordinary conditions of an unshaded greenhouse, the other within a cheesecloth enclosure in the same greenhouse. Some of these data are summarized in the form of graphs and shown in Fig. 1.

Although the interpretation of the plant values in terms of those derived from the instruments offers many difficulties, nevertheless several striking features of this environmental complex are registered by the plants and the instruments. Attention is especially directed to the general agreement between the radiation values and those of dry weight and leaf area.

These general relationships between sunlight and plant growth are interesting enough to warrant a more detailed examination by reviewing briefly the effects of the various components of sunlight upon the different physiological processes that take place in plants. The sunlight here considered is actually a very small fraction of the great electromagnetic spectrum.

As will be seen in Fig. 2, this immense series of wave lengths extends from far beyond the short gamma waves produced from radioactive matter, such as radium, to the long wireless radio waves. The enlarged portion shown below includes the wave lengths of the visible spectrum from red to violet. This, together with a section in the infrared and another in the ultraviolet, comprises the wave length regions considered in the present discussion.

In addition to the action of the different wave legths of light, the factors of

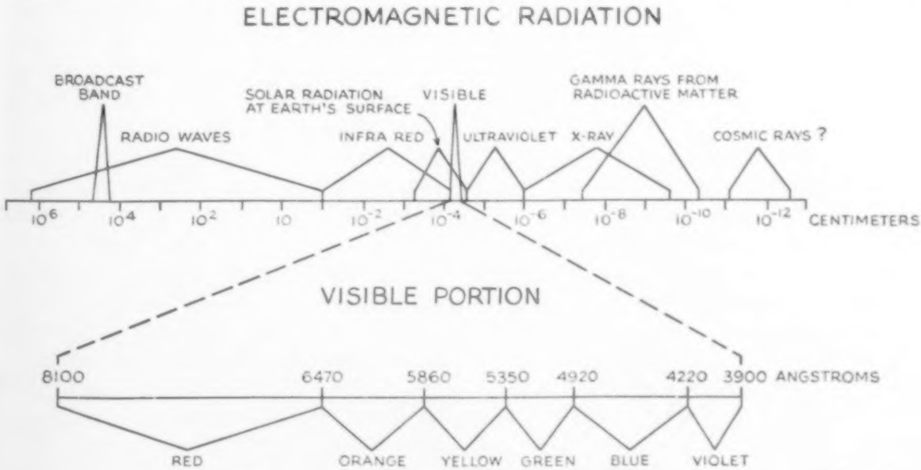


FIG. 2. ANALYSIS OF THE SPECTRUM.

SHOWING POSITION OF INFRARED, VISIBLE, AND ULTRA-VIOLET RADIATION IN THE GREAT ELECTROMAGNETIC SPECTRUM. DATA FROM DEMING AND COTTRELL AND FROM "HANDBOOK OF CHEMISTRY AND PHYSICS."

intensity and duration exert definite effects on the growing plant. Without going too much into detail, we shall first consider some of the interesting growth responses induced by different lengths of daylight.

Duration Effects

Every one has observed the remarkable regularity with which our common plants come into flowering with the advent of the different seasons. Among the early blooming plants in spring are the arbutus and forsythia, then the dogwood and later the iris, and so on into the summer and fall when the asters and chrysanthemums continue the floral display. Although temperature plays an important role, yet the main contributing climatic factor controlling flower production is the length of daylight. Plants like the cosmos, which normally flower in autumn when the days are short, can be made to flower at other seasons of the year by artificially limiting them to definite hours of light.

Numerous experiments have been carried out by Garner and Allard (1920), which conclusively demonstrate that plants may be made to produce flowers or to continue their vegetative growth by merely regulating the number of hours of exposure to daylight. The lengths of the daily light and dark periods were controlled by moving the plants in and out of darkened sheds.

These authors conclude from their many studies that plants which are sensitive to length of day fall naturally into two groups which are divided by a fairly definite critical light period. "In the short-day group flowering is initiated by day lengths shorter than the critical, and in the long-day group flowering is initiated by day lengths in excess of this critical period. . . . The essential characteristic of the less sensitive or indeterminate group of plants is that they possess no clearly defined critical light period.

Interesting plant responses to the length of the light period are illustrated by two experiments taken from the work reported by Garner and Allard (1925). In one of these the upper and the lower sections of a yellow cosmos plant were exposed to 10 hours of light. The middle section received light during the entire long summer days. Both the top and bottom sections of the plant responded to the characteristic short-day light exposures and soon bloomed, while the middle section remained vegetative to the long-day exposure. This would indicate a localized response.

In another set of experiments (Garner and Allard, 1931) artificial light was used, and the plants were exposed to this illumination for a total of 12 hours per day. One group received 12 hours of continuous light and 12 hours of darkness. The other groups were alternately illuminated and darkened for periods of the following durations: 1 hour, 30 minutes, 15 minutes, 5 minutes, 1 minute, 15 seconds and 5 seconds. Again using the yellow cosmos as an example, the interesting growth response is shown in Plate 1.

A progressive decrease in height, size and weight of the plants and an increase in etiolation were noticed down to the 1-minute interval. Further shortening of the light periods resulted in marked improvement in growth and general appearance. All exposure intervals less than 1 hour were equally unfavorable for flowering. In one of the long-day plants tried (rocket larkspur) none of the shorter alternations showed a retarding action in flowering, although the general growth responses were similar to those of the short-day plant. These are exceedingly interesting growth responses to the duration of light and to date no satisfactory explanation has been given.

A most interesting method of forcing greenhouse plants has been reported by Withrow (1933, 1934, 1936). Lamps of very low wattage used as supplemental

Courtesy U. S. Dept. Agric.

PLATE 1. EQUAL ALTERNATIONS OF LIGHT AND DARK ON YELLOW COSMOS. RANGING FROM 12 HOURS TO 5 SECONDS. WITH DECREASE IN THE INTERVALS OF LIGHT AND DARKNESS THERE IS PROGRESSIVE DECREASE IN HEIGHT, SIZE, AND WEIGHT OF THE PLANTS AND INCREASE IN ETIOLATION AND ATTENUATION TILL THE 1-MINUTE INTERVAL IS REACHED. FURTHER SHORTENING OF ALTERNATIONS CAUSES MARKED IMPROVEMENT IN GROWTH AND APPEARANCE OF THE PLANTS. ALL INTERVALS FROM 1 HOUR DOWNWARD ARE ALMOST EQUALLY UNFAVORABLE FOR FLOWERING.

lighting produced responses which were seemingly out of all proportion to the treatment. The plants were illuminated for several hours each night in addition to the natural light they received during the day. The intensities varied from less than 1 foot-candle to over 100 foot-candles. In Plate 2, very little difference in flowering is noted between the aster (Heart of France) receiving 100 foot-candles and the one receiving 0.3 foot-candle. Flowering even occurred with 0.1 foot-candle. This was an intensity about double that of moonlight on a bright winter night at Lafayette, Ind., where these experiments were performed.

The discovery of photoperiodism by Garner and Allard has attained widespread interest from the scientific as well as the utilitarian point of view. The extreme sensitiveness of plants to the length of light period has been shown recently by Borthwick and Parker (1938) with Biloxi soybean plants. As few as two short photoperiods were found sufficient to so change the development of the growing points that differentiation of flower primordia resulted. The time of blooming was influenced by the number of photoperiod treatments. Their (1938) anatomical studies also show the effect of supplemental light of very low intensity. "When plants are given an 8 hour photoperiod of natural light supplemented by 8 hours of Mazda light, initiation occurs if the intensity of the supplemental light is below 0.5 foot-candle, but does not occur if the intensity is above 0.5 foot-candle." It is thus seen that light of an intensity as low as 0.5 foot-candle or slightly higher may have definite action on the development of a plant.

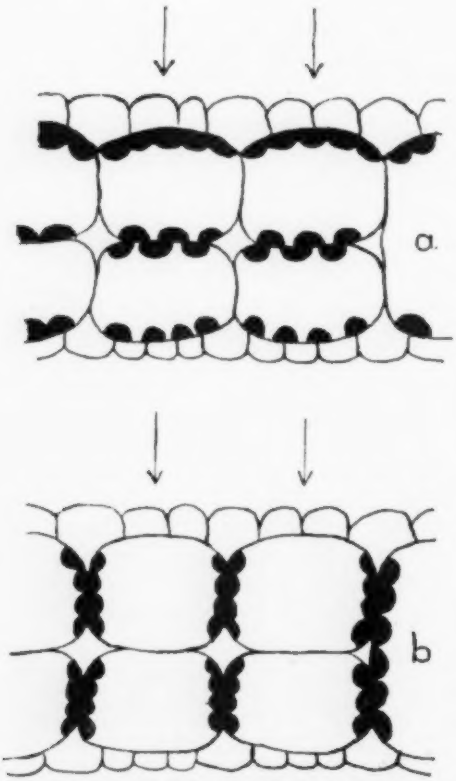
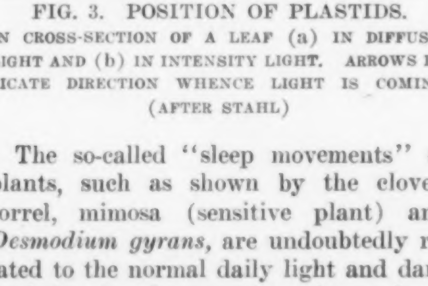


FIG. 3. POSITION OF PLASTIDS.
IN CROSS-SECTION OF A LEAF (a) IN DIFFUSED LIGHT AND (b) IN INTENSITY LIGHT. ARROWS INDICATE DIRECTION WHENCE LIGHT IS COMING. (AFTER STAHL)

The so-called "sleep movements" of plants, such as shown by the clover, sorrel, mimosa (sensitive plant) and *Desmodium gyrans*, are undoubtedly related to the normal daily light and dark periods. In the morning these plants



PLANT METABOLISM
REPRESENTING THE EXCHANGE OF OXYGEN AND CARBON DIOXIDE WHICH TAKES PLACE IN DARKNESS (LEFT) AND LIGHT (RIGHT).

open or unfold their leaves and at night close them. This daily rhythm of opening and closing becomes so fixed in the protoplasm of the plants that when they are placed in continuous darkness the movement may continue for several days; each day, however, it becomes weaker until it finally ceases.

Intensity Effects

There is scarcely a place on the earth's surface either too light or too dark for plants to grow. On the deserts we find plants adapted to intense sunlight. In caverns receiving little or no sunlight other types of vegetation are found. One of these "dark-loving" plants is a tiny moss (*Schistostega osmundacea*) equipped with a plate of cells forming a set of lenses capable of focusing the scattered light on its chloroplasts, those small bodies bearing the chlorophyll which is essential for photosynthesis.

Many plants exposed to daylight of varying intensities have developed certain characteristic responses which in many cases have proven beneficial. The English ivy (*Hedera helix*), for example, arranges its leaves in a mosaic pattern that exposes a maximum area to the light. Other plants, like the compass plant (*Silphium laciniatum*) and the wild lettuce (*Lactuca scariola*), turn the edges of their leaves in a general north-south direction. Thus when the light is weakest in morning and evening, the flat surfaces of the leaves are in a position to receive a maximum amount of light, whereas at noon, when the light is most intense, these surfaces are more or less parallel with the sun's rays and receive a minimum amount of direct radiation.

Even the interior of leaves frequently undergoes structural changes with increasing or decreasing light intensity. The microscope reveals in some instances a change in position of the chloroplasts within the leaf cells, as illustrated in Fig. 3. These chlorophyll-containing bodies arrange themselves across the path of

weak beams of light as shown in the upper figure, *a*. In strong light these bodies migrate to the side walls, thus permitting a minimum amount of exposed surface, *b*.

All increase of dry weight in plants depends on their assimilating carbon dioxide from the air under the influence of light. All the carbon in coal and wood, grains, oils and many other indispensable products comes, in the final analysis, from this source and depends for its energy content on sunlight. In Fig. 4 the gas exchange between a green leaf and its immediate environment is represented. It will be noted that while respiration goes on continuously in light and darkness, photosynthesis takes place only in light.

Sunlight intensity varies under natural conditions from 0 at night to as much as 10,000 foot-candles on a bright summer day. Most plants grow very well in intensities considerably under the high figure just noted. In experiments with artificial light good growth has been obtained with intensities as low as 2,000 to 3,000 foot-candles. Numerous experiments clearly show that plants under normal atmospheric conditions grow better and better as the light intensity is increased up to a certain value. Beyond this value there is no further increase. The excess radiant energy is apparently wasted so far as the process of photosynthesis is concerned. One naturally wonders why it is impossible to "push" the plant in its manufacture of sugar and starch. What holds back this all-important work of the plant? The answer is simple enough when the factors of photosynthesis are examined. Some idea of what takes place in the plant during photosynthesis may be expressed in the shorthand of chemistry:

Courtesy R. B. Withrow

PLATE 2. SUPPLEMENTAL ARTIFICIAL ILLUMINATION.
ON FORCING ASTER (HEART OF FRANCE) INTO FLOWERING.

$$\underset{\text{(carbon dioxide)}}{6CO_2} + \underset{\text{(water)}}{6H_2O} + \text{light} \rightarrow \underset{\text{(sugar)}}{C_6H_{12}O_6} + \underset{\text{(oxygen)}}{6O_2}$$

The raw products that are utilized in this process are carbon dioxide and water. Normal air contains about 0.035 per cent. carbon dioxide. Thus one can understand that as the process of manufacturing sugar is speeded up by increasing the light intensity there will come a point at which the rate is slowed down by a lack of carbon dioxide, which at this

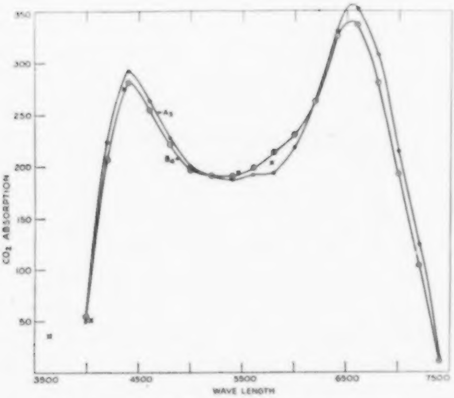


FIG. 5. WAVE-LENGTH EFFECT
OF LIGHT ON CARBON DIOXIDE ASSIMILATION OF WHEAT PLANTS. A_2, THE CORRECTED FORM OF THE CURVE OBTAINED WITH THE LARGE CHRISTIANSEN FILTERS; B_1, THE CORRECTED FORM OF THE CURVE OBTAINED WITH THE SMALL CHRISTIANSEN FILTERS. POINTS MARKED X, THE RESULTS OBTAINED WITH LINE FILTERS AND QUARTZ MERCURY ARC.

low concentration flows into the plant at a limited rate. If, however, the level of the reservoir of carbon dioxide be raised by increasing its concentration in the air surrounding the plant the work done by

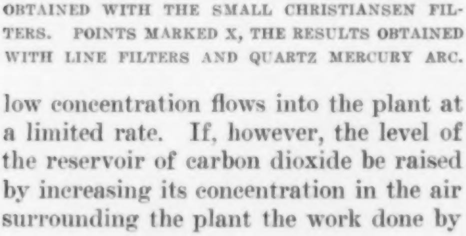


PLATE 3. WHEAT AT HARVEST.
AVERAGE CARBON-DIOXIDE CONCENTRATIONS RELATIVE TO AIR WERE A, 3.8; B, 1.1; C, 0.9.

the plant should be increased as the light intensity is further increased. This is exactly what was done in experiments with wheat (Johnston, 1935).

Three plots of wheat plants were employed in one experiment. One was open to normal air, and two were enclosed by glass cases 5 feet high with fly netting stretched across the top of each to reduce wind action. A pipe carrying a mixture of air and carbon dioxide opened into one of the enclosed plots, the other serving as the enclosed control. At the end of the experiment the growth in this carbon-dioxide-treated plot was compared to that in the enclosed control plot and to that in the open control plot.

The appearance of the three crops at harvest is shown in Plate 3. *A* received air enriched with carbon dioxide to about four times that of normal air. *B* was grown in the enclosed control plot, and *C* in the open. It was shown in these and other experiments that air enriched with carbon dioxide (1) increased the tillering of the wheat, (2) greatly increased the weight of straw, increased (3) the number and (4) weight of heads, (5) increased the number of grains produced and (6) slightly delayed the time of heading.

It is thus seen that under artificial light and sunlight conditions the process of photosynthesis may be limited by the amount of carbon dioxide in the air rather than the intensity of the light.

Wave-length Effects

Photosynthesis is, perhaps, the most important reaction in the whole world, for life itself would perish without it. On the chemical side, much remains to be done. The complexity of organic chemical reactions, the little-understood effectiveness of so-called catalysts, the behavior of enzymes, of colloids, of hormones, altogether make up a field of research of the utmost interest, but extremely complicated. It is, however, in-

teresting to examine it from other points of view.

Photosynthesis takes place under the influence of light. Its energy is derived from radiation. The question immediately suggests itself, "What rays are utilized in this reaction?" Although many qualitative studies of this problem have been made, there is but little quantitative data on the subject, especially with economic plants. Hoover (1937), of the Smithsonian Institution, has made quantitative determinations of the dependence of an important higher plant—wheat, in this case—on the wave length of light for the assimilation of atmospheric carbon dioxide. He used the ingenious Christiansen filter (McAlister, 1935) to separate narrow bands of the spectrum from the beams of a group of Mazda lamps surrounding the tall glass tube within which the wheat was grown. Atmospheric temperature and moisture were controlled. A continuously operating device measured the change of carbon-dioxide concentration in the slow air stream which bathed the plants. The effects observed depended on the color of light employed. Three series of experiments were made. In one, Mazda lamps with Christiansen filters were the light sources. In a second series, the discontinuous line spectrum of the mercury arc combined with glass filters gave monochromatic sources. In the third, sunlight itself, passing through a large-sized Christiansen filter some 60 feet from the plant, furnished floodlights of nearly monochromatic rays. The results, illustrated graphically in Fig. 5, were in close accord from all three series.

From the data of these experiments it would appear that red rays are most promotive, blue rays second, green and yellow rays useful, while the infrared and the ultraviolet contribute nothing to the assimilation of carbon dioxide in wheat.

Somewhat similar results were obtained for the growth of a lower plant. Meier (1936) grew a green alga *Stichococcus bacillaris* Naeg. under equal light intensities but in four different wave-length regions. Good growth, as measured by cell multiplication, was obtained in the blue, red and yellow lights, but none in the green.

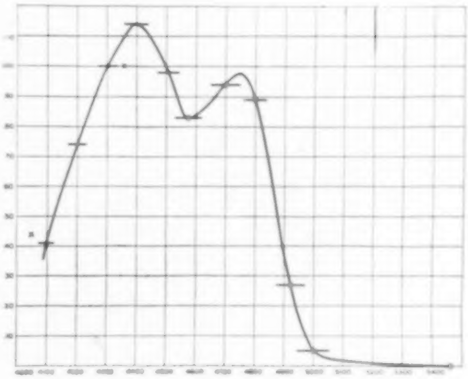


FIG. 6. PHOTOTROPISM OF OAT SHOOT
PHOTOTROPIC SENSITIVITY CURVE; THE ORDINATES ARE RELATIVE SENSITIVITY VALUES, THE ABSCISSAE WAVE-LENGTHS IN ANGSTROMS, AND THE HORIZONTAL BARS INDICATE THE WAVE-LENGTH RANGES OF THE BALANCE POINTS.

PLATE 4. OAT SEEDLING.
PHOTOTROPIC CURVATURE RESULTING FROM A DIFFERENCE IN ILLUMINATION ON OPPOSITE SIDES.

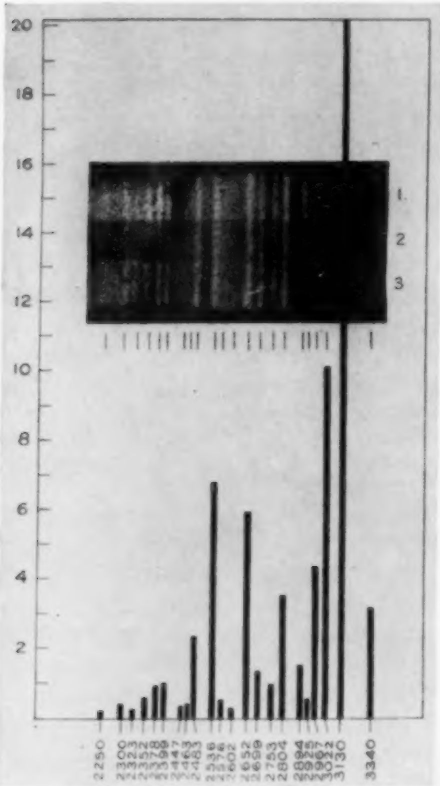


PLATE 5. AN ALGAL SPECTROGRAM.
OBTAINED BY EXPOSING A PLATE OF CHLORELLA VULGARIS TO ULTRA-VIOLET RADIATION FROM A QUARTZ MERCURY LAMP FOR (1) 64 MINUTES, (2) 16 MINUTES, AND (3) 32 MINUTES. THIS SPECTROGRAM IS SUPERIMPOSED ON A DIAGRAM OF INTENSITIES (ORDINATES IN THOUSANDS OF ERGS/-SEC./CM^2) OF THE WAVE-LENGTHS (ABSCISSAE IN ANGSTROMS).

In the growth response of English ivy to light intensity, the leaves arrange themselves in a mosaic pattern with a maximum of leaf surface exposed to light. The leaf stems or petioles turn toward the light source. Ordinary house plants, such as the geranium, show this same response as they grow by a well-lighted window. Unless such plants are turned occasionally, the stems will grow out toward the light, giving them a lopsided appearance.

From superficial observations it would appear that light hinders or retards elongation of plant cells. It is frequently noted that the stems of many plants grow more rapidly at night than during the day. Potatoes send forth greatly elongated shoots in a darkened cellar; if these same potatoes were permitted to remain in strong light, the sprouts would be very much shorter and the internodes greatly reduced.

In the case of plants illuminated on one side it is noted that the shaded sides of the stems have stretched more than those receiving direct illumination. The uneven rate of growth on the opposite sides results in curved stems and a general appearance of the plant turning toward the light. This characteristic bending is very well illustrated with the oat sprout shown in Plate 4. Because of its convenience in handling and its ready response to light the oat seedling has been used very extensively in phototropic studies.

Although superficial observations clearly indicate that the sensitivity of the plant toward radiant energy is such that it reacts differently to light and darkness, the question as to its sensitivity to different colors or wave lengths of light is not so readily answered. To obtain an answer a plant might be placed half-way between two equally intense lights, for example blue and green, and the direction of bending noted. The plant's sensitivity to different colors could thus be determined in a general way. Such experiments have been conducted by the Smithsonian Institution to determine growth sensitivity to wavelengths of light (Johnston, 1934).

The general procedure used in studying the wave-length effects in phototropism, as this type of response is termed, is to place an oat seedling between two lights of different color. After a time interval the seedling is examined for a one-sided growth. If, for example, with the seedling exposed to blue light on one side and to green on the other, a distinct bending was noted toward the blue light, it was then known

that the blue light exerted a greater retarding action, since the side of the seedling toward the green light grew more, thus bending the seedling toward the blue light. The lights were then so adjusted as to increase the green, or decrease the blue intensity. Another seedling was used and the process repeated until a balance point was obtained where the effect of one light neutralized the effect of the other in such a manner that the seedling grew vertically. When this point was determined a specially constructed thermocouple replaced the seedling, and by means of a galvanometer the two light intensities were measured.

From a number of such experiments the curve shown in Fig. 6 was constructed. This curve illustrates the sensitivity of the oat seedling (plotted vertically) to the wave lengths of light (plotted horizontally). The sensitivity increases rapidly from 4100 A to 4400 A, then falls off somewhat to about 4575 A, and again rises to a secondary maximum at about 4750 A. From this point the sensitivity decreases rapidly to 5000 A, from which point it gradually tapers to 5461, the threshold of sensitivity on the long-wave-length side. Briefly, it may be concluded that the region of greatest sensitivity is in the blue. That is, growth is retarded most by blue light. Orange and red light have no effect in retarding the growth of these oat seedlings.

Recent investigations indicate that phototropic curvatures are associated with the auxin—or growth substance—contents in the illuminated and shaded sides of the plant organs. Light in some way either inactivates the auxins on the illuminated side or causes them to migrate to the shaded side, or perhaps does both, thus resulting in greater cell elongation on the shaded side. Considerable work yet remains to be done before the exact mechanism is fully understood. Experiments are now in progress at the Smithsonian Institution to study more fully the exact relationship between light intensity and wave-length and growth substances found within plants.

An interesting phenomenon closely paralleling phototropism has been observed for a certain type of seed germination. It was found that the short wave-lengths of light—violet, blue and green—inhibited the germination of light-sensitive lettuce seed, and that the long wave-lengths—yellow, orange and red—promoted germination. Flint and McAlister (1935) exposed seeds to a sufficient amount of red light to bring about a 50 per cent. germination by superimposing upon them the prismatic spectrum of a Mazda light. The resultant germination, as influenced by different wave lengths, is shown in the form of a curve in Fig. 7.

Had the seeds not been exposed to the spectrum, their germination would have been 50 per cent. as represented by the horizontal dash line. The germination of seeds exposed to wave-lengths lying approximately between 4000 and 5200 A was inhibited. That between 5200 and 7000 was greatly promoted. An interesting and heretofore unobserved phenomenon was found in the red at about 7600 A. Here also germination was inhibited. Although this inhibitory region in the red has not been detected in phototropic responses, it may have been overshadowed by other effects not yet properly isolated.

Experimentation has clearly demonstrated enormous differences in response of living plant tissues to different wave lengths of radiant energy in the visible spectrum. When such interesting reactions occur in visible light, one becomes curious as to what effects are found with wave-lengths shorter than the visible violet and with those longer than the visible red. A single example in each of these two regions will illustrate some of the effects found.

The harmful action of ultra-violet radiation is familiar to all; its painful action

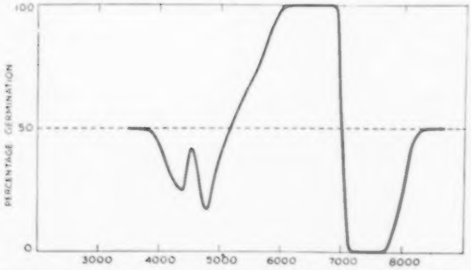


FIG. 7. LETTUCE SEED GERMINATION. PERCENTAGE GERMINATION (ORDINATES) OF LIGHT-SENSITIVE LETTUCE SEED IN DIFFERENT WAVE-LENGTH REGIONS (ABSCISSAE) OF THE SPECTRUM AFTER AN EXPOSURE TO RED LIGHT SUFFICIENT TO EFFECT A 50-PER CENT. GERMINATION.

has been felt by most of us at the bathing beach after our first "outing" of the season. Its lethal action on micro-organisms has been studied by many experimenters, especially in connection with the treatment of disease. The "scare" headlines of the daily press designate it as the "death ray." Ultra-violet radiation covers a wide range of wave-lengths. These different wave-lengths have their specific characteristics just as truly as the wave-lengths in the visible spectrum.

The Smithsonian Institution has been interested in the specific action of these ultraviolet wave lengths on green algae, one of the lower forms of plant life. Using the variety *Chlorella vulgaris*, Meier (1936) has grown cultures on agar plates and exposed them to the ultra-violet spectral lines of a quartz mercury vapor lamp. The intensities of 20 different wave-lengths ranging from 2250 A to 3022 A were carefully measured and their effects studied with respect to their lethal sensitivity and to their radiotoxic virulence or speed of effectiveness in killing the cells.

An algal spectrogram with distinct areas of dead cells is shown in Plate 5. A photograph of an algal plate exposed to the ultra-violet spectrum has been superimposed on a diagram representing the intensities of the different mercury lines. Three exposures are here shown: (1) 64 minutes, (2) 16 minutes, (3) 32 minutes. The wave-lengths are noted across the bottom of the diagram. The heights of the vertical bars represent radiation intensities in thousands of ergs/sec./cm². It was from plates and data like these that the radiotoxic spectral sensitivity and virulence were calculated. Maximum lethal sensitivity occurs at 2600 A, and there is a change of virulence with decreasing wave-length, which reached a high maximum at 2323 A.

Later studies show that a stimulative action causing increased cell multiplication of the green alga *Stichococcus bacillaris* Naeg. results from sublethal exposures to the four short wave-lengths 2352, 2483, 2652, and 2967 A. The optimum stimulation point occurs for each of these wave-lengths at approximately two-thirds of the lethal exposure. The stimulative action is not transitory but has persisted in the cultures over a period of 2 years.

Next, consider a case in the near infra-red, just beyond the visible red of the spectrum. In one experiment (Johnston, 1932), tomato plants were grown under two sets of wave-length conditions. In one, only visible light was present; in the other, near infra-red radiation was added to the visible. Although the near infra-red plants were taller and heavier, their appearance was far from normal. A marked decrease in chlorophyll was apparent in the leaves and a distinct yellowing and death was noted in some cases. It appears that if this near infra-red region is not actually destructive to chlorophyll, it is of little or no benefit to its formation.

In connection with a discussion of ultra-violet and infra-red radiation effects, it is interesting to note that in the experiments of Arthur (1932) on the production of pigment in apples, coloring was increased by ultra-violet radiation, while near infra-red radiation alone or in the presence of visible light had a marked detrimental effect. Under these

rays a typical wrinkled, necrotic area soon develops.

Much progress has been made in our knowledge of sunlight and the manner in which it affects plants. As experimental science has improved, artificial light sources were used because their variables could be controlled better and the conditions of the experiment repeated fairly accurately. In a last analysis, artificial light is modified sunlight. Duration experiments can be controlled better with artificial light than with sunlight. Although the intensity of artificial light is less than that of full sunlight, yet for many purposes it is sufficiently great. The most vital difference between sunlight and artificial light lies in the quality or wave-length distribution. An examination of the curves shown in Fig. 8 may help make this point clear. Compared with the energy distribution curve of solar radiation are similar curves constructed from tungsten filament radiations at two different temperatures. Attention is called to the position of the maximum of each curve. In the tungsten this is in the infrared, whereas in sunlight it occurs in the yellow. Other artificial lights may likewise be compared with that of the sun. Each shows a characteristic departure from a perfect or even fairly good match. Even filters combined with artificial lights have failed to give the desired similarity. It will be a distinct step forward in this type of research when an artificial light source is developed that has an energy distribution curve similar to that of solar radiation.

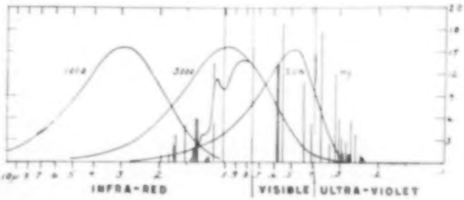


FIG. 8. RADIATION CURVES.
DIAGRAM OF RELATIVE ENERGY EMISSION CURVES FROM A BODY AT 1,000° K. (DULL-RED THERAPEUTIC LAMP) AND AT 3,000° K. (HIGH-TEMPERATURE TUNGSTEN LAMP) COMPARED WITH THAT FROM THE SUN AND FROM A MERCURY ARC IN QUARTZ. RADIATION FROM A TUNGSTEN LAMP EQUIPPED WITH A 1-CM WATER CELL IS ALSO SHOWN.

Since plants have been growing on the earth for millions of years it is reasonable to assume that their physiology is adjusted best to sunlight. Although there is experimental evidence to show that different processes go on better in some wave-lengths than others, yet the exact relationships of each should be studied separately under well-isolated portions of the spectrum. With better light filters and with the construction of new light sources it is hoped to break white light into narrower and narrower spectral regions of sufficient intensity to study more accurately the many reactions that take place in the living plant—reactions upon which life itself depends.

ON THE ROCK-STRUCTURES AND PLANTS OF OLD RAG MOUNTAIN, VIRGINIA

By Dr. TITUS ULKE
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THE mountainous region investigated comprises roughly an elliptical area, covering four by six miles, enclosing scenic Old Rag Mountain and bounded by Hughes River on the northeast side toward the village of Nethers, Popham Run towards Etlan, Robertson River toward Nicholson's Farm on the west, and by Brokenback Run on the north toward Weakley Hollow. Most of it is

now included in Shenandoah National Park.

Ragged Run is a picturesque stream heading at 2,500 feet elevation half a mile from the peak and running southeasterly for about three miles into Popham Run near Etlan, and forming, at lower levels, a series of pools under gray boulders and sweet birches.

The name "Old Rag" is, no doubt, a diminution of "The Old Ragged Mountain," given it on account of the rather

Photo by W. Howard Ball

FIG. 1. THE CREST OF "OLD RAG," FROM THE ROAD TO NETHERS, VA.

Photo by Dorothy Justus

FIG. 2. DIKES OF GRANITE ALONG THE RIDGE TRAIL

ragged or frayed appearance of its long crest-line against the sky (see Figs. 1, 2 and 3).

It is usually climbed by one of two well-marked Appalachian Club trails, the first, or "Ridge Trail," starting at a mile beyond Nethers at about 900 feet elevation and ascending toward the peak by a zigzag course of some three miles, eventually along the highly scenic crest-line, while the second, known as the "Saddle Trail," leads westwardly from the peak for a third of a mile and then drops steeply, northwesterly, for about a mile down to a road leading from the abandoned Old Rag P. O. to Nethers, a distance of about three miles and a drop of about 1,000 feet. Nethers lies about thirteen miles by road southwest of Sperryville, Va.

The backbone and all the higher points of Old Rag, which culminate in a peak 3,291 feet high, are composed of a grayish granite, which is frequently weathered into roughly rounded blocks, as shown in Fig. 4, or heaped up into weathered pinnacles and wall-like bastions of giant stepping-stones, as seen in Fig. 5.

At several places along the trails there may be noted veins or intrusive masses of basalt and quartzite, the quartz in the latter occasionally of a striking bluish tint, due, it is believed, to the diffractive effect of inclusions of microscopic crystals of rutile.

Photo by Wm. H. Ball

FIG. 3. VIEW FROM SUMMIT TOWARD MADISON VALLEY

Movement of the rock masses, especially near the crest-line, have occasioned cracking and faulting, and produced several vertical corridor-like passageways, or "couloirs," and horizontal cave-like chambers, open at each end, in which hikers may find welcome shelter from storms.

Among the rather uncommon birds found flying about or nesting on Old Rag we noted the following: northern raven, cerulean warbler, Bewick's wren, black

Photo by Isham W. Perkins

FIG. 4. THE HIGHEST POINT ON "OLD RAG"

vulture, ruffed grouse, duck hawk and chuck-will's-widow, most of which breed on the mountain, according to Mr. E. J. Court, who has collected their eggs.

A few mammals were observed, namely, the short-tailed shrew, opossum, skunk and red squirrel, as well as a few specimens of the common mountain rattlesnake.

But the unusual flora of Old Rag is probably of most interest.

At lower elevations giant-leaved umbrella trees (*Magnolia tripetala*) and striped maples (*Acer pennsylvanicum*) are quite abundant. On wet rocks along Robertson's River on the west slope is found the long-leaved lettuce saxifrage (*Micranthes micranthidifolia*).

In the deciduous woods bordering the ridge trail at 2,500 feet elevation, and above, during last May (1939), were blooming many thousands of the lovely large-flowered wake robin (*Trillium grandiflorum*)—a never-to-be forgotten spectacle! In the saddle between the two highest summits T. Ruhoff and I discovered two specimens of a unique *quintuple-flowered* variety of this beautiful trillium. At about 2,500 feet elevation could be seen a number of fine specimens, in bloom, of the yellow moccasin flower and a dozen plants of an unusual *all white-flowered* variety of the showy orchis. The yellow moccasin flower (*Cypripedium parviflorum*) is also found in rich soil along the road above Brokenback Run.

At higher elevations along the ridge trail, in pockets of weathered granite, or peaty soil, were observed Michaux's saxifrage, rough heuchera and bristly sarsaparilla (*Aralia hispida*). At 3,000 feet elevation near the Ridge Trail occurs a solitary red spruce tree (*Picea rubens*).

On the northwest slope, immediately below the highest peak, the following

Photo by Isham W. Perkins

FIG. 5. BASTION OF GRANITE NEAR THE SUMMIT

plants were found associated growing in shallow sandy or peaty soil covering the granite:

Mountain holly (*Ilex montana*), pigeon cherry (*Prunus pennsylvanica*), cinnamon fern, sweet fern, wild live-for-ever or sweetheart stone crop, hair sedge (*Stenophyllus capillaris*), mountain laurel, and finally, black chokeberry (*Aronia melanocarpa*).

Several of the above-mentioned plants have not been discovered as yet in the Stony Man region of Shenandoah National Park, located only five miles north of "Old Rag," while such species as the oak fern, Fraser's balsam fir, trailing wolfsbane, American mountain ash and red-berried elder have been found growing in the vicinity of Stony Man Mountain, but not, so far as is known, on "Old Rag." The chief cause for this difference in occurrence and floral preference, no doubt, lies in the differing nature and composition of the rocks and soil in the two contrasted, but adjacent, regions.

Along the main crest of the Blue Ridge, as substantially followed by the Skyline Drive of Shenandoah Park, the rocks are chiefly greenstones or altered lavas, flanked on the south and east slopes by coarsely crystalline granite or granitoid rocks, such as *unakite* (epidote-porphyry) at Milam Gap and along the upper reaches of Rose River, while, as stated, granite alone forms the crest and main body of Old Rag Mountain.

ORGANISM, SOCIETY AND SCIENCE

III. SCIENCE

By Dr. R. W. GERARD

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Now what of science in the epiorganism? That it is most responsible for the changes our civilization has undergone, and for the accelerating rate of change, there is no question. Invention is the greatest national resource—the Indians on this continent did little with all that was here available to them; and the method of science, as I have put it elsewhere, "is the flowing river that deposits a rich alluvial delta of new-made wisdom. It is the greatest invention of man, the method of invention." Science, alone of human achievements, is strictly cumulative and forward looking. We look back to creative peaks in religion—Confucius, Moses, Christ; in art—Homer, Shakespeare, Leonardo, Beethoven; even in philosophy; but the science of Newton, Lavoisier, Helmholtz, even of the recent Michelson, Fischer and Loeb, is dwarfed by greater heights of to-day and the still more towering ones of to-morrow. Newton was correct, despite his modesty, in saying, "If I saw further, 'twas because I stood on Titan's shoulders."

Of course, if science is responsible for the good, it may be blamed for the bad; and there can be little doubt that it has accelerated the specialization of units faster than the mechanisms for integration of them, with attendant org conflicts and disintegrating stresses. (Even here Compton has pointed out that x-rays alone have saved more lives in the time since their discovery than high explosives have destroyed, World War included. On the other hand, the obsolescence of equipment and of individual knowledge is prodigious.) But though knowledge of the physical world is ahead of that of man and his societies, and new material objects, though resisted, find far easier acceptance than new ideas, still it can hardly be questioned that science will be able to produce social inventions to provide the needed integration and to control the mechanical ones.

Need I add that by "science" I do not mean the preserves of cloistered laboratory workers alone, but the collective achievement of all serious students in all fields who apply to the problems they face the tested knowledge of the past and the critical method of experimentation and evaluation. Those whose "decisions are reached after due instruction in, (search for), and evaluation of the facts, pro and con; and (whose actions), while not always correct, (are) rational in the light of the evidence and, since action generates new evidence, (are) automatically self-corrective," are functioning scientifically. As Norris says, "The authority of the scientist, for his fellow men, does not consist in the vigor of his speech or writing. It consists in his exhibition of the postulates of his thought, and of his objectives, and of how he came by these, and in his exhibition of his evidence, and of how he secured this."

Is the expectation that science will create effective mechanisms for better integration of the epiorganism a pious hope or a reasonable hypothesis? Our org analysis and the study of hierarchical homologies will help to answer this question. I have earlier homologized the scientist in the epiorganism with the receptors of the metazoan. It is possible to go further and pair the natural scientist with the exteroceptors, which inform the

organism of its surroundings, and the social scientist with the interoceptors, which act largely via the autonomic nervous system to regulate and coordinate the parts of the organism. Surely the environment of the epiorganism is no longer only nor mainly set by its material substrate and geographical boundaries. Mental horizons, the advancing frontiers of knowledge and understanding, are now the crucial ones. Social action and evolution, like that of the organism, depend on new stimuli which emerge from the unsensed and unknown as ever more specialized receptors become sensitive to them. The scientist and his elaborate apparatus are just such an epiorgan for exploring the unknown, with increasing penetration and discrimination. Leonardo said, "All knowledge is vain and erroneous excepting that brought into the world by sense perception, the mother of all certainty." And Lord Rayleigh, in an interesting address to the British Association, pointed out in detail that the apparatus of the scientist, far from superseding or opposing our common senses, merely extends them. The telescope, microscope and electron microscope are modifications of the lens system of our eye, for far or close vision; the spectroscope improves our resolution of color; photography, the photoelectric cell and now television extend the spectral range and sensitivity of the retina, etc. As a result of such methodological improvements, atoms, once hypothetical, are traced and counted and genes are seen and mapped.

Social Evolution

I have also pointed out the crucial and dominant role played by receptors in the evolution of axiate symmetry, over-all gradients of dominance and subordination, and of the central nervous system and its suprasegmental cortex. In view of the innumerable other parallels with the organism, in its structure, function, and history, I see no reason for doubting that the epiorganism will follow a further evolution along these same lines. Science is the mass of partially organized sense perceptions of the epiorganism, presenting to the org ever more complex problems requiring unified action. And some sort of epicortex, or brain, must be forced into existence, as living orgs have always met (by whatever mechanisms) the demands of adaptation.

The rudiments of such a social brain already exist in the philosophers and other creative artists and thinkers and in statesmen—though these latter are perhaps more in the nature of cerebellum than cerebrum. And, although President Lowell could, with some justice, cite the entomologist, Wheeler, for an honorary degree as an "eminent student of the ants, who has shown that they *also* can conduct a complex society without the use of reason," it is still true that, "To the extent that man acts rationally, he makes progress in the battle with chaos, and he and his society become more integrated and more complex. Irrational behavior, directed by emotion when intelligence is uninformed or in abeyance, is sooner or later retrogressive."[8]

Not only a brain homologue, but also many other new epiorgans must be evolved by societies. How will this come about? I am convinced that the pressure of events will shape them, willy-nilly, but this does not mean that man's intelligence will not be a major instrument through which necessity operates. Remember that our reason and moral sense, like our chromosomes and brains, have themselves been created by evolution,

[8] A friendly critic states "irrationality to date has varied directly with the extension of communication." It is true that as formal education or informal education via magazines, newspapers and radio is extended to ever larger groups, it becomes watered down; but only as these groups are reached and progressively educated can they be taught to depend more on intelligence and demand more information.

have persisted and developed under the action of natural selection, and must have real survival value to the epiorganism in which, alone, they come to expression. In some respects volition and choice serve for society as does gene selection for the individual; and the exercise of our best collective judgment and foresight must certainly accelerate social evolution.

For example, it is futile to point to the corruption of men by power and the prostitution of high position for selfish ends. Human nature can certainly be changed in so far as standards and objectives of behavior are concerned; and many groups of men—the early Christians, the Russian revolutionaries, members of the learned professions largely—have forsworn the common goals of their day for others personally more acceptable. Neither money nor prestige nor the power they beget elicit from men such effort or sacrifice as do often the motivations of love for others, self-respect, and intense conviction. It is possible to achieve on a far wider scale than at present, though it is even now not rare, the attitude toward high office that it offers trust and demands service rather than that it presents a base for plunder. And, pending this, it is surely not so difficult to render such posts less attractive to the opportunist; for example, by requiring complete and permanent retirement from public or business life after a certain period in office. Few adventurers sought a night as a bridegroom of the storied princess when the morning brought the executioner.

More particularly for the scientists as such, some constructive suggestions for action have been voiced. We must recognize first that science does not exist independently of society but under its control—is it not true that the amount and direction of research is deeply subject to the flow of funds from government (one fourth for military objectives), from industry, from the foundations and lesser donors—and that it in turn has a tremendous influence on its epiorganism. Scientists are fortunately beginning to recognize and accept this responsibility.[1]

And what constructive moves can scientists make to further social integration? First, perhaps, they should put their own house in order and eliminate the present unnecessarily great duplication of effort and facilities, uncoordinated experimentation and knowledge, confused and excessive publication, and the like. This can be done without sacrifice of flexibility and without a sterilizing regimentation, and fears of increasing integration and eliminating some of the existing chaos in this org are no better grounded than in the case of the greater org of society itself. Bernal, in his volume on "The Social Function of Science," has presented this matter exhaustively.

Second, scientists should reestablish closer reciprocal relations with the community at large. As Bragg put it, science now suggests an engine steaming ahead while the line of cars it should pull, left uncoupled, remains behind. Or, in org terms, the scientist is not exercising, as he should, the gradient control which his role of receptor confers upon him. Hogben fairly points out that if the scientist reasons without action, it is partly his responsibility that wayward youth acts without reason. When the org determiners are weakened, new zooids form. Popularizing science (its attitude and method and intellectual structures rather than a display of striking facts it has dug up)—"selling" science—is vital to its own further healthy development no less than to that of society. Citizens educated to the intellectual virtues which science teaches—tolerance and the questioning mind, intellectual honesty, release from superstition—and possessing the

[1] Such an organization as the American Association of Scientific Workers, dedicated to the problems of science in society, is a healthy consequence.

elements of our present knowledge of evolution, genetics, psychiatry, would not voluntarily forbid free speech and reasonable social experimentation nor long tolerate a dictator who did so.

And a tradition of learning is not new nor esoteric. I well recall the horror of my Vermont neighbor, whose grandparents were the first settlers in a section of this Indian infested wilderness, when I remarked, at the conclusion of an especially vivid story he passed on of frontier hardships, that probably there was no time to learn reading and writing in those hurried days. In indignation he exploded, "Why, every mother taught her children to read and write as the first duty to civilization." Certainly in earliest colonial days our people demanded and received schools and seized all educational opportunities. Washington's admonition in his farewell address has a prophetic ring. "Promote, then, as an object of primary importance institutions for the general diffusion of knowledge. In proportion as the structure of society gives force to public opinion, it should be enlightened." Government is always with the consent of the governed, but whether this consent is obtained by force or by persuasion is largely a matter of the enlightenment of the mass of people. It is because of this that government propaganda is directed to deliberate public confusion and falsification in proportion to the governors' basic dependence on force. When censorship withholds the necessary facts even reason is helpless.

As for further details of a program for socially conscious scientists, there are such problems calling for evaluation and solution as: criteria for the selection of leaders and other functional units—capacity and vocational test devising on a far greater scale; human breeding control, as to both kind and number, positive selection and negative as well; study of the motivations of men and their origin and control via cultural anthropology and psychiatry; devising and testing new social machinery, applying the method of science to the epiorganism as it is being applied to the organism. The details of a program are less important now than that scientists, *qua* scientists, should themselves thrash through these questions and, if unable to agree on what should be done, agree at least on what investigative procedures will give sound information as to what should be done—and get them under way.

Nor is it quixotic to suggest that scientists could really get action in society once they were reasonably agreed on what was desirable. Bodies composed of government officials and representatives of formal science already exist and will rapidly increase, bodies which now study and will one day help guide the impact of scientific inventions on society. I have elsewhere suggested the possibility of a central body, such as the National Academy of Science, controlling scientific patents. It could not be very long before funds and power were built up to any desired level. And, of course, a concerted refusal of scientists to contribute their services would effectively block a modern war, or dictatorship. I introduce these considerations not necessarily to advocate any of the specific measures mentioned but only to emphasize that scientists need have no fear that their considered efforts at social betterment will be frustrated by lack of power. Indeed, the reverse danger is greater, that organized science might obtain more power than it can yet wisely exercise.

Future of Society

And now a final word about the future of society, the further evolution of the epiorganism. Unless the consistent indications of a great range of biological knowledge are all erroneous, the epiorganism will move toward increasing integration. The intraorg determiners will

increase and operate further, faster, more specifically, and, especially, with greater power. Units will become more specialized and interdependent, present epiorgans will improve in function and new ones appear. The individual will be more and more a part of the whole state, though it will remain meaningless to ask the question, "Does the citizen exist for the state or the state for the citizen," since reciprocal influence is the essence of an org. With greater integration will come new sensitivity and more efficient and complex behavior—improved adaptive amplification.

Does this, then, mean that the present totalitarian states have evolved a step beyond the more democratic ones and point our future fate or hope? I think not. Note first that the democracies also have moved steadily toward integration, the accepted institutions of to-day are the socialist Utopias of yesterday; and recall, further, that living orgs deploy in many experimental ways while but few of the resultant forms survive the test of adequate adaptation. Natural selection passes only the most successful products through its sieve. What characteristics of Nazi Germany, for example, can be rated good or bad from the broad biological viewpoint?

The greater cohesion of the society, *per se*, is surely good. The intense nationalism produces, first, isolation and, second, overspecialization for conflict. The latter is as obviously dysgenic as the oversized tusks of the extinct sabre-tooth or the ponderous shell of the archaic king-crab. Isolation and fixation of type also result from the suppression of minority (or is it majority?) opinion and the general interference with free exchange of ideas. Isolation of animal stocks has always stagnated their evolution—witness the clumsy, early-evolved but long outdistanced mammals of the Australian fauna—and its consequences are even more drastic at the epiorganismic, ideational level. Whitehead has stated the case against uniformity with great cogency:

> The differences between the nations and races of mankind are required to preserve the conditions under which higher development is possible. One main factor in the upward trend of animal life has been the power of wandering. Perhaps this is why the armour-plated monsters fared badly. They could not wander. Animals wander into new conditions. They have to adapt themselves or die. Mankind has wandered from the trees to the plain, from the plains to the seacoast, from climate to climate, from continent to continent, and from habit of life to habit of life. When man ceases to wander, he will cease to ascend in the scale of being. Physical wandering is still important, but greater still is the power of man's spiritual adventures—adventures of thought, adventures of passionate feeling, adventures of aesthetic experience. A diversification among human communities is essential for the provision of the incentive and material for the Odyssey of the human spirit. Other nations of different habits are not enemies; they are godsends. Men require of their neighbours something sufficiently akin to be understood, something sufficiently different to provoke attention, and something great enough to command admiration. We should even be satisfied if there is something odd enough to be interesting.

The rule by force rather than by consent we have seen gives an unstable org; and the complete acceptance of the ethic that might makes right is a reversion to a superseded, and so presumably less adaptive, stage in the evolution of human and social morality, that of the paleothalamus rather than of the neo-cortex. And, lastly, anti-intellectualism and the prostitution of science is a deliberate gouging out of episense organs; the epiorganism so mutilated will blunder along blindly indeed. Intelligence and cooperation have overcome selfish strength over and over on the testing grounds of evolution—the small cerebral mammals superseded the huge spinal dinosaurs, and a herd of elk is rarely attacked by predators. In all but its basically progressive totalitarianism, then, Germany is making an experiment which biologists

must evaluate as unsound and evolving an epiorganism that seems doomed to extinction in the struggle for survival.

But there is danger. The magnification of material power, by technological achievement, in advance of the development of adequate org controls, might lead to disruption of the whole into chaotic zooids or individuals. Cro-Magnon was exterminated by a seemingly inferior race which possessed the bow and arrow; vandals might destroy civilization again as they once did under Genseric; stones from the mass had far more chance of overwhelming the Bastille than they will have of overcoming the machine guns of a tyrant's police. My guess is that this will not happen; but even if it should, living orgs will again, as ever in the past, succeed in their ceaseless but winning battle against chaos and continue to evolve. Whether some present forms of society remain to be modified or whether all become extinct and are supplanted by other forms, epiorganisms will advance to greater integration and better adaptation.

And in either case, the scientist and the philosopher along with the artist, the explorers and thinkers and creators, must bear the major responsibility. In the eyes of the biologist, they must be at the head of the quantitative gradient. In the words of the poet, O'Shaughnessy, which I extend to all these groups:

> We are the music-makers,
> And we are the dreamers of dreams,
> Wandering by lone sea-breakers,
> And sitting by desolate streams;
> World-losers and world-forsakers,
> On whom the pale moon gleams:
> Yet we are the movers and shakers
> Of the world for ever, it seems.
>
> With wonderful deathless ditties
> We build up the world's great cities,
> And out of a fabulous story
> We fashion an empire's glory:
> One man with a dream, at pleasure,
> Shall go forth and conquer a crown;
> And three with a new song's measure
> Can trample a kingdom down.
>
> We, in the ages lying
> In the buried past of the earth,
> Built Nineveh with our sighing,
> And Babel itself with our mirth;
> And o'erthrew them with prophesying
> To the old of the new world's worth;
> For each age is a dream that is dying,
> Or one that is coming to birth.

THE MANY-CENTERED WHOLE

Each man sees the world through his own eyes. It is inevitable, therefore, that there should be, in relation to knowledge, a kind of personal centripetal tendency. One's own sensations, one's own point of view, one's own interests have a vividness and a validity which give them, for each one of us, an understandable priority.

Choose off the shelves a group of learned treatises and sample the prefaces: *Mathematics*—it is the queen of the sciences; *Physics*—it is the source of the basic laws for the behavior of all matter; *Chemistry*—a recent text says, "Chemistry touches all human interests. It is the central science"; *Biology*—it assaults the greatest mystery of all, the mystery of life; *Astronomy*—it has the cosmos and eternity for its heroic theme; *Psychology*—it analyzes the mental processes which we must use on other problems; *Logic*—it deals with the laws of reason itself; *Philosophy*—it is an examination of the ultimate questions which give life meaning. And so one could expand the list, with brave and startling claims for the central character and basic importance of one field, one specialty, one segment of knowledge after another. . . .

The web of knowledge is vast and intricately interconnected, with threads radiating in all directions in such a way as to make each fact, when one closely examines it, a veritable center. A biochemist in Holland reports something new about the symmetry of complicated molecules in certain tissues—and every cancer expert in the world focuses his attention. An American develops a method of speeding up electrified particles in a sort of glorified merry-go-round—and out run the radiating and unpredictable threads of connection all over the world and throughout the whole web of scientific knowledge, touching a specialist in intermediary metabolism in New York, a physicist in Paris, an anemia specialist in Rochester, a geneticist in Russia, a cancer specialist in Boston, a metallurgist in Tokyo, a cellular physiologist in Copenhagen, a radiologist in St. Louis.—*Raymond B. Fosdick, President of the Rockefeller Foundation, from "A Review for 1939."*

HOSPITALS AND THE ADVANCEMENT OF SCIENCE

By Dr. CHAS. E. REMY

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To overthrow superstition, to protect motherhood from pain, to free childhood from sickness, to bring health to all mankind; these are the ends for which, throughout the centuries, the scholars, heroes, prophets, saints and martyrs of medical science have worked and fought and died, . . .

—*Yandell Henderson*

A FEW weeks ago I chanced to pick up the magazine section of a Sunday morning paper and read, for the first time, the story of Dr. John Gorrie and his invention of a machine for making ice. I was deeply moved by the simple tale and will attempt to recite it here, in extreme brevity, as an introduction to my paper.

John Gorrie was born, of Scotch-Irish parentage, in Charleston, South Carolina. It happened that he became Dr. John Gorrie some years later through graduation from the College of Physicians and Surgeons of New York. After a very brief period of time spent, following graduation, in Abbeville, South Carolina, he moved to, and opened an office for the practice of medicine in Apalachicola, Florida. This was in the year 1833.

Young Dr. Gorrie arrived to find Apalachicola sunken into a veritable slough of despond as the result of an overwhelming epidemic of malaria; he found Florida, then still a territory, beginning to despair of achieving statehood because of this raging, devastating, ever-spreading fever. Neighboring states were beginning to suffer from the inroads of the disease. The part played by mosquitoes in the dissemination of malaria was at that time unknown.

Like many of his contemporaries, this young physician was imbued with the idea that this debilitating and malicious fever took its origin and virulence from certain very noxious vapors and gases, which in turn took their origin from the lowlands and swamps. Heat apparently accentuated both the vapors and their virulence, since the disease undoubtedly took on a new impetus during the warmer seasons. He therefore reasoned that, if he might keep his patients surrounded by cool air, the effect from the poisonous fumes might be lessened.

For more than ten years Dr. John Gorrie worked and strove with this idea. We need not list his encouragements or his discouragements. In 1845 he accidentally came upon the fact, in the course of his experiments, that the lowering of the temperature of the air was but a step removed from, and in line with, the producing of ice by artificial means. The United States and Mexico were at war at that time, and every border hospital was clamoring for ice with which to cool the hospital rooms, where malaria was killing more soldiers than all the battles of the war. This proved to be the added impetus which he needed to carry him onward to his goal. In 1850 Dr. John Gorrie demonstrated ice-making with a machine of his own manufacture, utilizing essentially the same principles of heat absorption through gas expansion, which are employed generally for refrigeration to-day.

It was as a direct result of his care of the sick in hospitals that Dr. John Gorrie was stimulated and inspired to the invention of an ice-making machine. Today practically each and every major industry of the world has a causal reason, in some one of its ramifications, for paying him heartfelt tribute, and millions of private homes will be his debtor for all time to come. Regardless of these facts, Dr. Gorrie died on June 16, 1855, a dis-

couraged man who was quite unaware of the greatness of his contribution to the human race and toward the advancement of science.

Through the medium of their inspiration to those persons employed in, or professionally associated with them, hospitals have played, and continue to play, an ever increasing part in promoting the advancement of science and the forwarding of scientific education. We have not always remembered this fact, or possibly stressed it as much as we might have done when we were soliciting in behalf of our own particular neighborhood hospital. The public at large, which after all is just another way of saying "you and I," have not always remembered it when making their contribution to the local hospital or community fund drive. But I am confident that the thought has not been consciously evaded by either "we" or "they" with the intent to escape the very evident inherent social and financial obligations which lie dormant in the idea. It has only been due to the fact that great thoughts, great people and great achievements often walk silently and unobtrusively beside us for long periods of time unrecognized and unsuspected. To an unusual degree has this been true of hospital achievement and influence. It is time for the world to awaken.

Hospitals typify one of civilization's most modern, as well as most lauded concepts, that of accomplishment through group cooperation. Hundreds and sometimes thousands of individuals in a single hospital go daily about their varied, yet particular and specific duties in different parts of the hospital; simultaneously, in nearby or in distant portions of the institution, they perform seemingly quite unrelated acts and tasks; yet all collaborating none the less, as parts of a carefully coordinated whole, in contribution toward the final end result, that some John Doe, of whom most of them have never heard and may never hear, shall be saved from invalidism or death.

The modern hospital has become a complicated managerial and administrative problem by reason of its many facets; by the fact of the very multiplicity of its activities. Of no other institution in the world can it be more aptly remarked that it is made up of wheels within wheels. Nearly every one of them is a very plain, simple little wheel, but there are so many of them, and all different. The administration of a bath by a nurse to a patient is not in itself inherently a very complicated procedure; neither is the administering of the medicines which may have been prescribed; nor the sweeping of the floors, the washing and ironing of the linen, the making of beds, the shoveling of coal, the preparing and cooking of food; all these things are but simple routines. The distribution of alms in one form or another, the keeping of the account books, the purchase and disbursement of supplies, the collection of bills, the maintenance of records, are all such ordinary activities as to be familiar, for the most part, to almost every adult man and woman. There is nothing awe-inspiring or gruesome or mysterious or complicated or superstition-stirring about any of these activities, which constitute the bulk of hospital work. To the physician, the surgeon, the pathologist, the pharmacist, the laboratory or x-ray technician, the anesthetist or the nurse, their various respective routines have become just as common and prosaic through frequent and multiple repetition. Yet all these many and varied and simple routines, seemingly so unrelated, actually so closely knit into the essential pattern of hospital efficiency, have not only served to develop and to maintain for hundreds of years a certain sense of awe and mystery in relation to the thought of a hospital, but have in addition thereto somehow managed to exert a forceful influence in behalf of the forward trend

of civilization itself, including its handmaiden science.

Hospitals, from times almost immemorial, have consisted of, or been constituted by, an army of men and women, each age or era contributing its quota as troop or regiment or battalion, of that army; an army so great and so vast in the total aggregate as to appear numberless and unending; an army which has never retreated, which faces always forward toward the enemy, and which marches ever on and on, its beginnings lost in the intangible mists of the infinite past, its destination equally undiscernible in the hazy distances of an even more infinitely distant future. It is an army composed and made up of physicians, maids, dietitians, chaplains, nurses, seamstresses, cooks, orderlies, hospital trustees, priests, porters, scientists, day laborers, clerks, hospital superintendents, ambulance drivers, waitresses, health department officials and personnel, boards of public welfare of great cities, laundresses, social service and medical social service workers, engineers, electricians, scholars, savants, nuns, plumbers, pipefitters and other classifications too varied and numerous for mention. It is an army girt for service, for battle, self-sacrifice and travail. It is an army all members of which have dedicated their lives and works to the aim and end that disease, if not death itself, shall finally be made *"to vanish from the earth."*

A great forward step was made in the outlook for hospitals and their coworker science, with the advent into the former of the physicians' private patients, and conditions improved very rapidly thereafter. It gradually became apparent that every up-to-date facility and scientific aid to diagnosis and treatment could be grouped together in the hospital and thus be made available to all physicians and their patients; facilities and equipment ordinarily quite beyond financial reach of the large majority of physicians as private office equipment. Confidence in the merit of hospital service took on a greater solidarity, and as this developed and grew larger in the minds of doctors and patients alike, step by step new innovations were made; pathological and bacteriological laboratories were added; one by one x-ray, dietetic and other special services took their place in the hospital ensemble; interest in the scientific investigation of disease processes and their causal factors became tremendously stimulated. It was inevitable that ultimately the scientific minds of the entire world began to visualize and finally grasped a comprehension of the latent possibilities of hospitals as a fertile field for the advancement of science not only in relation to the human body, but in relation to the welfare of all mankind, and the preeminent evidence of this may be remarked in the ever growing and closer affiliation between hospitals and the more important colleges and universities.

It is impossible to garner here examples showing how the hospital has inspired men to scientific discoveries and inventions in almost every known field of research and forward-looking achievement. The one isolated example of Dr. John Gorrie has been cited from many thousands of similar individual services to science and mankind which have taken their germination from inspiration supplied by hospitals. Time does not permit mention of others. Viewing hospitals in perspective, however, our subject may not rightly be abandoned without stressed mention of one of the special divisions of these wonderful institutions.

The hospital laboratory, with its batteries of scientific apparatus and instruments of precision, has probably done more than any other one factor, in or out of the hospital, to relegate empiricism and the trial-and-error methods of yesterday, to the rearmost shadows of that great humanitarian stage, known as the practice of medicine, whereon there is

daily played, all over the world, the never-ending drama of life and death. The hospital laboratory is a domain wherein the microscope, both figuratively and actually, holds the center of the stage. To those who will look carefully it reveals the existence, around and about them, of another fantastic and seemingly infinite world, crowded and teeming with life, in the midst of which mankind lived for hundreds of thousands of years, totally unaware and unsuspecting of its existence; a universe within a universe, containing myriads upon myriads of living creatures which eat and drink and reproduce their kind and fight and die, but which are so small that a colony made up of many thousands of them might veritably rest upon the point of a needle and thereon remain invisible to the unaided human eye; creatures differing as widely in their types of form and structure and in their habits and customs as the various members of that larger, visible animal and vegetable kingdom of which we ourselves are an integral part; armies of builders and armies of wreckers, each as energetic in its respective realm as Maeterlinck has so vividly pictured the busy bee; groups with potentialities for good and groups with potentialities for evil, so immeasurable in comparison to those same traits as found in man and his brother animals of the visible world, as to cause these latter to fade into pale insignificance.

The hospital laboratory has become the chemical warfare and intelligence divisions combined of that world-wide army which is devoting its energies to the fighting of disease, pestilence and death. It is at one and the same time a sentinel ever on guard to warn of the approach of stealthy or unsuspected foes; a prompt and efficient scout and messenger to give word of the battle's trend; a powerful telescope to render visible the approach of an attacking enemy while the latter's armies yet remain indistinguishable to the unaided human eye; and a factory for the manufacture of munitions of war, with which to put the armies of dread disease to rout. The laboratory as the secret intelligence and research bureau serves not only in the formulation of plans and campaigns against the enemy, but likewise for the discovery and development of those mysterious and marvelous deadly chemical formulae, through the discovery and later dissemination of which the foes of life and health are slowly, one after another, overcome or held at bay pending reinforcements from the same trustworthy source. It is a citadel of offense and defense, and it is quite commonly the final determining factor as to whether the besieged shall repulse the enemy or be overcome in the battle and perish.

Physicians, chemists, engineers and others of the hospital field have given many discoveries to the world, ranging in level of importance from insulin, for protection of the diabetic, to devices as simple or simpler than the humble safety pin. The friends, relatives and patients of the one or the other, inspired by hospital needs or hospital aspirations, have likewise contributed their quota. In the outlook of the laboratory alone the vistas of possibility are beyond the realms of comprehension. As the modern packing-house industries have gradually found use for nearly all of what were formerly, at one time, the waste products of those industries, so, many fold over, are the possibilities in the outlook of our hospital laboratories. Latent in every one of those many thousands of organisms which inhabit that world which was opened up to man by the microscope, lie possibilities for discoveries of wonderful and stupendous import to science; who knows but from that wonder-land which they inhabit, the secrets of life and death themselves may not some time be wrested. The potentialities of the contributions of hospitals toward the advancement of science have only been faintly scratched; the forward march has only just begun.

BLUE JAY: BRIGAND OR BENEFACTOR?

WHAT DID THE BLUE JAY DO WITH THE NUT?

By Dr. ARNOLD GESELL
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It took place on a bleak autumn afternoon (November 21) in New England in a thickly settled residential district on a street busy with automobile traffic. It concerned an urban squirrel and a metropolitan blue jay in swift sequence as follows: At 1:45 a gray squirrel, answering my tapping signal, ran up a rustic incline which leads to a window box, to secure a nut (papershell pecan) which I offered him through an open window. At 1:46 this squirrel scampered back to the lawn to a point about 15 feet away. He buried the nut and raked a brittle oak leaf over it. At 1:47 the squirrel returned to the window box for a second nut. Immediately a blue jay flew down to the precise spot where the first nut had just been buried, pecked vigorously through the oak leaf into the soil, and in about 30 seconds seized the nut in his bill and disappeared with swift and sudden flight into a towering elm near by.

I had no wish to worsen the reputation of the blue jay; but his alertness was so clever and his acquisitiveness so adept that I reported the incident in a brief note to *Science*.[1] Somewhat venturesomely I included the question, "What did the blue jay do with the nut?"

This question evoked such interesting responses from varied observers that a summary report in Scientific Monthly now seems in order. Whether such a summary will place the blue jay in a more favorable light, the readers will judge for themselves. Meanwhile we shall quote with approval the November 13, 1858 entry in Thoreau's Journal: "It is the more glorious to live in Concord because the jay is so splendidly painted."

On the evidence now available any one of the following possibilities deserves consideration:

1. The blue jay ate the nut.
2. The blue jay cached the nut as a thrifty investment to be eaten at a later date after frost and moisture had softened the shell.
3. The blue jay cached the nut; the squirrel retrieved it and ate it. In which event, it has been suggested an old adage again applies, "He laughs best, who laughs last."
4. The blue jay planted the nut; and it grew into a beautiful tree!
5. The blue jay ate only part of the nut; dropped most of the kernel which was eaten by a beneficent species.

1. The blue jay ate the nut. This possibility is vouched for by Thoreau himself in a passage of his Journal (November 10, 1858) which tells us clearly how the blue jay accomplished the feat:

> Hearing in the oak and near by a sound as if some one had broken a twig, I looked up and saw a jay pecking at an acorn. There were several jays busily gathering acorns on a scarlet oak. I could hear them break them off. They then flew to a suitable limb, and placing the acorn under one foot, hammered away at it busily, looking round from time to time to see if any foe was approaching, and soon reached the meat and nibbled at it, holding up their heads to swallow, while they held it very firmly with their claws. (Their hammering made a sound like the woodpecker's.) Nevertheless it sometimes dropped to the ground before they had done with it.

This, however, is not an invariable method of eating. A correspondent, a psychologist, from Mississippi, frequently finds shells of nuts, with

[1] Volume 89, p. 35.

meats mostly extracted, wedged in cracks of fence posts or in the crotch of branches. It appears that natural cracks, chinks and pits serve as holdfasts for the nuts which are pecked by the blue jay. W. E. Ritter has noted this behavior in the acorn storing of the California woodpecker. He also remarks that the California jay is almost as devoted to oaks as is the woodpecker; but finds that the jay typically buries the nuts in the ground for future use.

Another correspondent, a pharmacologist, also from Mississippi, corroborates Thoreau: "I have frequently seen blue jays pluck the nuts (pecans) from the tree and fly with them in their bill to a limb of the same tree, and while holding the pecan nut on the limb with the claw of one foot, vigorously pick the nut open with the bill and devour the contents."

A correspondent, a pharmacologist from Tennessee, reports that blue jays as well as crows infest the wild pecan trees near Memphis and consume great numbers of the nuts. Many times he has observed a blue jay perched on a limb cracking the nuts by hammerlike blows of the head. This is after the manner of woodpeckers, but the jay holds the nut in his bill and pounds the nut against the limb or stump, which serves as an anvil. (The director of the Texas Agricultural Experiment Station has observed that a blue jay after pounding a nut against the trunk of the tree deliberately dropped the nut to the ground, recovering it and dropping it two or three times, perhaps with the object of letting the fall break the hull. "The dropping did not appear to be accidental, as the bird dropped the nut each time immediately after picking it up.")

"Furthermore," continues our Tennessee observer, "the blue jays will literally riddle an oak tree of its acorns, even when the acorns are between a half and three quarters of an inch in diameter, and scarcely easier to crack than a pecan. . . . I therefore," adds this correspondent, "feel no hesitation in worsening the reputation of the blue jay."

In similar vein, a plant pathologist of the United States Department of Agriculture from the Pecan Field Laboratory in Georgia:

> I wish to inform you that the blue jay is Public Enemy No. 1 of the pecan industry throughout the South, especially the Schley, which is a very thin shell variety. We estimate that in some instances blue jays destroy one pound of pecans daily. Not that they eat this many but they carry them off to some nearby evergreen tree such as magnolia or live oak and pound them against the limbs while holding the nut in their beaks. In most instances these nuts fall to the ground and the blue jay flies away for another nut. Therefore the ravages of this bird causes the pecan growers to patrol their orchards with shotguns and a large number of these pests are killed every year in the South in this manner. In my opinion it is impossible to worsen the reputation of Mr. Blue Jay down here, although we all think that he is a very beautiful bird.

2 and 3. The blue jay cached the nut —to be eaten later by himself or by a squirrel! With respect to these two possibilities, our data are meager but suggestive. It seems that squirrel and blue jay are at more or less constant war with each other, even in Chicago. A correspondent from that city reports that when a squirrel in his back yard had cached a peanut, two blue jays watchfully circled overhead and then swooped down and got the nut. This happened several times. But on a later occasion the squirrel "pretended" to bury the nut in one or two places before actually burying it in a true cache. When the jays came down to a false place they screamed, but by persevering they finally retrieved the cached nut.

There can be no doubt that the urban squirrel before hiding a nut often displays an indecisive kind of behavior which resembles feigning. Is this a ruse —a protective expedient against excessive robbery by blue jays?

One correspondent reports the performance of two gray squirrels who

showed no such cunning. These, however, were wilderness squirrels without any Chicago background. In Berkshire midwinter over a period of thirty minutes or more individual peanuts were fed alternately to the two gray squirrels. Each time the squirrel promptly stored the nut in the recesses formed by the loose bark of a hemlock tree. No sooner stuffed away, the squirrel came back for another nut. "But spying from above unobserved and relentless was the culprit blue jay, recovering each nut. No time to fly away, no chance taken of missing a morsel; every one devoured. . . . I mourn," says the correspondent, "about adding fresh insult to the jay, but not more so than over the stupidity of the gray squirrel."

Coming back from wilderness to metropolis, we have the honor to report a confirmatory observation made by William Beebe from the west window of his Tropical Research Laboratory in the New York Zoological Park. The window opens on an extent of lawn enclosed by shrubs and trees.

> This is a favorite place for the nut caches of gray squirrels. Scores of acorns are buried, some within a yard of the window.
>
> This last autumn at least two blue jays have systematically robbed the squirrels. One bird which I watched perched in a nearby tree. Within two minutes after a nut was pushed down and covered up by a squirrel, the jay was on the spot, and soon unearthed the acorn. It then flew up, perched for a few seconds, then returned to another part of the lawn, and jammed the nut into the ground, driving it home with repeated blows of its beak. This happened at least four times within an hour, and perhaps oftener. Two jays repeated this performance many times within a period of several weeks.

For similar reasons, Mable Osgood Wright is compelled to compare the blue jay with a robber baron and indeed calls him the "azure-plumed jeering bandit." However, she thinks that the squirrels in the end have decidedly the best of it, for they frequently find the very holes where the jays have hidden their plunder!

4. The blue jay planted the nut and it grew into a beautiful tree! For this theory we have no less an authority than Thoreau and Forbush's monumental monograph on the birds of New England, published by the Commonwealth of Massachusetts. By burying nuts and seeds blue jays rear forests. In a few years these birds can replant a stretch of cleared land. They reforest not only by regurgitating and eliminating seeds and by dropping nuts while feeding or in flight, but by actually tamping them into the ground.

Thoreau was led to investigate this very matter in the autumn of 1860, just after Emerson had planted a lot with acorns. Says the Journal of Thoreau:

> I have come out this afternoon to get ten seedling oaks out of a purely oak wood, and as many out of a purely pine wood and then compare them.
>
> As I am coming out of the pine wood, looking for seedling oaks, I see a jay which was screaming at me, fly to a white oak 8 or 10 rods from the wooded pasture and directly alight on the ground, pick up an acorn, fly back into the woods with it. This was one, perhaps the most effectual, way in which this wood was stocked with the numerous little oaks which I saw under that dense white pine grove. Where will you look for a jay sooner than in a dense white pine thicket? It is there they commonly live and build. . . .

Squirrels and jays may be enemies, but in reforestation Thoreau concludes both serve man: "So far as our noblest hardwood forests were concerned, the animals, especially squirrels and jays, are our greatest and almost only benefactors. It is to them that we owe this gift."

5. The blue jay fed the bobwhite with the nut. This is our condensed version of possibility number five, though here the pecan is symbolic of the acorn, and the bobwhite is specifically a habitant of Walker County, Texas. Our authority is a most interesting investigation, under the auspices of Walter Taylor, senior biologist of the Texas Cooperative Wild Life Research Unit, United States Department of Agriculture. Two of his

field biologists (Lay and Siegler), aware that the acorn is a favorite food of the quail, made a quantitative measurement of jay activity to determine whether there was any connection between the food habits of the jay and food availability for the quail. It seemed extremely doubtful that the few squirrels and the hogs (one hog per 69 acres) could supply sufficient mast for the quail.

Census and estimates showed one blue jay to every 313 acres; and a crop of 42,000 acorns for a selected red oak; and 100,000 acorns for a water oak. The jays not only plucked off acorns to fly away with them, but picked them off, and pecked at them dropping particles, so that the ground beneath the tree was strewn with pieces of acorn. Actual count and calculation showed that 11,400 acorns of the red oak and 26,000 of the water oak were made available to quail by jay. These numbers are so great that the blue jay is adjudged to be "very likely the most important link between the acorn and the quail in woodland type as exemplified in Walker County, Texas."

If the blue jay needs a feather in his cap, this biological linkage must not be overlooked. However, there is little danger that the blue jay will suffer any injustice. He has so many admirers. Even the informed ornithologist who sets him down with the crow as being in general an injurious species, is likely to regard him as an engaging rascal. There is such a strong sentiment in favor of him "due to his interesting personality" that the Audubon societies and nature lovers keep him off the blacklist of birds excepted from the protection which is offered desirable species. Audubon himself characterized blue jay (*Cyanocitta cristata*) as "one of our commonest, wisest, most beautiful birds." Even if he is a sort of Ishmael among feathered tribes, he is, insists Wilson Flagg, "a true American. He is known throughout the continent and never visits another country."

What if he is the bad boy of the bird neighborhood and the terror of small birds?—so runs the apologia, "He is also a devoted husband and father who shows his best traits in the family circle." Forbush even notes that blue jays care for the aged and infirm. He cites an observation which "tells of an old, worn, partially blind blue jay that was fed, tended, and guarded by companions who never deserted him. They guided him to a spring where he bathed regularly, always with some of his companions close by him."

Despite his cannibalistic fondness for eggs and nestlings, does he not also eat injurious creatures such as the hairy caterpillar, gypsy moth, brown tail, tent and sphinx moths, fruit-feeding beetles, and grasshoppers? And despite his audacious insolence is there not "a dashing reckless air about him that makes us pardon his faults?"

The scream of the jay to the poet-naturalist of Concord was a true winter sound. "It is wholly without sentiment and in harmony with winter."

Ah, but the blue jay is more than a strident screamer. In exalted moods he becomes a ventriloquist, capable of exquisite mimicry. For this we have the high testimony of Dr. P. L. Hatch. A blue jay was singing and "the notes which fell in showers like dew drops, almost inaudible, were among the clearest, most delicate, sweet and melodious that ever found their way into a human ear. I was in an ecstasy of wonder and surprise. . . . If a diet upon canary brains and mocking birds' eyes can afford such inspiration, these songsters contribute as much in their deaths as in their lives, and the regally plumed blue jay should live forever."

GENERAL FORMAL EDUCATION BY FIELD OF EMINENCE

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UNDIFFERENTIATED data such as those presented in a recent study[1] are of unquestioned value for general discussions of the relationship of social prominence and general formal education, but mass data always hide so much that is significant that the effort required to analyze the general population into its component populations according to significant characteristics is justified. One of the most important characteristics is field of eminence or vocation, concerning which contemporary information as well as a small amount of material on trends over the last quarter of a century are available. The present paper is thus an extension of the discussion of general formal education by separate consideration of data on some important fields of eminence.

Table I contains the most recent data available from "Who's Who in America." The medical profession stands out as the only group all members of which report an equivalent of a college degree, compared with only 72.4 per cent. college graduates for the entire group who reported adequate educational data. Next in order were educators, chemists, army and navy officers, geologists, clergymen, other scientists, lawyers and technical engineers, each with more than 72.4 per cent. of its members college graduates. The smallest percentage of college degrees was held by persons prominent in art (8.5), but almost three fourths had attended art schools. Actors and other persons prominent in the theater and motion pictures had almost as poor a record of college graduation (8.7 per cent.) and had less formal education than any other group, 41.7 per cent. having completed their formal schooling in the grades.

Prominent musicians also prove to have had a smaller than average amount of college training. Music school or college training was reported by about three fourths of them, however. Editors and newspaper writers, business men, writers, agriculturists and public officials have received considerably less formal education than the total group. The artistic groups are thus below average in formal education and the professions are at the other extreme. And persons in such practical pursuits as business, newspaper work, agriculture and public office are between the other two groups, although more similar to the former.

TRENDS

So incomplete are data showing changes in educational background for different sorts of leaders that the best procedure will be a separate review of the information for each field of eminence. In *authorship* it appears, according to one line of reasoning, that formal education has not made very rapid progress in the United States, especially for persons of highest quality. Clarke's important study of prominent American writers born before 1850 disclosed that 55.5 per cent. of those whose education was known had completed the college course, and an additional 16.4 per cent. had attended college. Only 15.3 per cent. had never reached secondary school, and only 4 per

[1] Mapheus Smith, SCIENTIFIC MONTHLY, 46: 551–560, 1938.

TABLE I

PERCENTAGE OF PERSONS LISTED IN "WHO'S WHO IN AMERICA" REPORTING DIFFERENT TYPES OF EDUCATIONAL BACKGROUND, CLASSIFIED BY FIELD OF EMINENCE, 1934[a]

Occupation	Total No.	No. with sufficient educational data	Percentage: Total	Only common school education	Secondary school education	Art school education	Music school education	Non-graduates of colleges	College graduates
Authorship	2,058	1,983	100.0	14.2	11.5	1.4	0.0	22.0	50.9
Journalism	1,269	1,248	100.0	14.0	11.5	1.0	0.0	24.9	48.6
Art	924	859	100.0	6.3	2.3	76.4	0.0	6.5	8.5
Music	483	403	100.0	12.7	10.4	0.0	38.2	17.4	21.3
Theater and motion pictures	158	127	100.0	41.7	23.6	6.3	0.0	19.7	8.7
Chemistry	215	215	100.0	.4	1.9	0.0	0.0	5.6	92.1
Geology	116	116	100.0	.9	.9	0.0	0.0	9.4	88.8
Other science	491	490	100.0	3.1	1.6	.4	0.0	7.1	87.8
Technical engineering	927	914	100.0	4.2	4.2	.1	0.0	14.6	76.9
Medicine	1,988	1,988	100.0	0.0	0.0	0.0	0.0	0.0	100.0
Religion	2,849	2,835	100.0	.8	.9	.04	0.0	9.7	88.54
Education	6,013	5,998	100.0	.3	.5	.5	0.0	1.8	96.9
Law	3,789	3,743	100.0	3.9	3.2	0.0	0.0	10.6	82.3
Public office	1,341	1,314	100.0	12.1	9.7	0.0	0.0	19.0	59.2
Army and Navy	506	493	100.0	2.4	2.4	0.0	0.0	4.1	91.1
Business and industry	5,810	5,524	100.0	16.8	15.3	.2	0.0	17.9	49.8
Agriculture	314	309	100.0	11.0	13.6	0.0	0.0	20.1	55.3
Miscellaneous	1,830	1,779	100.0	7.1	7.1	2.3	0.0	16.0	67.5
Total	**31,081**	**30,338**	**100.0**	**7.0**	**6.1**	**2.6**	**0.5**	**11.4**	**72.4**

[a] Compiled from tables in "Who's Who in America," 1936–37, pp. 2706, 2708.

cent. had never completed the grammar school course.[2] Even in 1934 only 72.9 per cent. of the prominent writers had attended college and 14.2 per cent. had never attended secondary school.

However, it is reasonable to believe that Clarke's and the "Who's Who in America" data are not closely comparable. Clarke's data distinguish various kinds of writers not included in the more recent classification. He subdivided his subjects into patrons, librarians, actors, orators, publicists, narrators, erudite writers, popularizers, speculative writers, prose writers, poets and dramatists. In the first four groups there were too few individuals to make the classes statistically significant. But for publicists about as large a proportion of persons had college education as was true for the group as a whole. For narrators the college group was smaller than for the average of the whole group. Erudite writers were above the group averages in college education, as were the popularizers. The speculative writers were even further above the average in college education. Prose writers and poets had a smaller than average proportion with this level of training. Thus the types with most college education, in order, were speculative writers, popularizers and erudite writers,[3] two of which classes, speculative and erudite writers, do not appear among the "Who's Who in America" authorship group. It is therefore safe to assume that the educational level of Clarke's group was raised by the inclusion of a number of persons who were both writers and teachers or who com-

[2] E. L. Clarke, "American Men of Letters; Their Nature and Nurture," *Columbia University Studies in History, Economics and Public Law*, Vol. 72, 1916, p. 67. Alfred Odin's prior study of French literary figures should also be mentioned. He reported that about 98 per cent. had education of the level of what was college grade in the United States. Compare Odin's "Genèse des Grands Hommes," Paris, 1895, pp. 526–27, with Lester F. Ward's "Applied Sociology," New York, 1906, pp. 216–219.

[3] Clarke, *op. cit.*, p. 67.

bined writing with professional interests. For a group including only the sort of writers embraced in the "Who's Who in America" classification Clarke's subjects, therefore, might be expected to have reported less formal education. What adjustment would have to be made can not be determined, but this line of reasoning suggests that the literary group of the present generation does have a somewhat larger proportion of college-trained persons than in earlier generations. In support of this argument is evidence from the first edition (1899) of "Who's Who in America." At the turn of the century only 27 per cent. of the authors reported college graduation.[4]

Prominent American *editors and journalists,* on the whole, have shown a considerable gain in educational status during the last third of a century. Of those first listed in "Who's Who in America" only 33 per cent. had completed college.[5] In comparison, 45.3 per cent. of the editors and newspaper writers added to the list in 1928 had completed college.[6] In 1934 the percentage rose to 48.6.

Educational data on *artists* are difficult to interpret, partly because most art training is carried on in private or semiprivate groups, and there is no uniform system of accrediting for art schools which tends to give formality to educational standards. Data from such sources as "Who's Who in America" suffer from this situation so much that their usefulness is but slight. Only the 1934 tabulation includes art schools as a separate category, but the flexibility of meaning of this term is so great that comparability with data on education of other occupational groups is very dubious. It is equally questionable if satisfactory comparisons can be made between the various classifications of "Who's Who in America" data. For example, of the 129 artists first listed in "Who's Who in America," 1928–29, and reporting educational data, 25, or 19.4 per cent., reported college degrees,[7] but in 1934 the corresponding figure was 8.5 per cent. In 1899 the percentage was 8,[8] compared with 13.9 for the 1910 data.[9] The variation over this period is presumptive evidence of inconsistency of the returns, due either to carelessness in reporting or to inadequacies in the report forms at one or another time. Some of the training in art schools of the 1934 list probably was given as college training in 1928, and some of those not reporting education in 1910 probably had the same type of education as those recording art school education in 1934, simply because there was no way of reporting art education in 1910 and no other formal education had been obtained or was considered worth recording. Under these conditions it is impossible to determine trends in education of outstanding American artists from "Who's Who in America" data. We do not know whether art school education or college education has increased for the group or what changes have taken place in the other educational categories of the formal educational background of such people.

Data on *musicians* are subject to some of the same difficulties as those for artists. In 1899, 36 per cent. of the "Who's Who in America" musicians did not furnish educational data.[10] In 1910, 36.4 per cent. of the musicians listed did not record preliminary educational data,[11] and in 1934, 16.6 per cent. reported insufficient educational data for analysis, compared with 31.9 per cent. who reported musical education. Since musical education is not included as a category of the

[4] E. G. Dexter, *The Popular Science Monthly,* 61: 247, 1902.

[5] *Ibid.*

[6] "Who Who's in America," 1930–31, p. 26.

[7] *Ibid.*

[8] Dexter, *op. cit.,* p. 247.

[9] "Who's Who in America," 1910–11, p. xxv.

[10] Dexter, *op. cit.,* p. 247.

[11] "Who's Who in America," 1910–11, p. xxv.

1899 and 1910 tabulations, strict comparability can not be obtained. However, college training increased and common school training decreased, if we can accept the reports on these items alone. Of the 1899 list, only 6 per cent. were college graduates,[12] compared with 19.4 per cent. in 1910[13] and 21.3 per cent. in 1934. We still can not be sure of the accuracy of these data, but it seems probable that the errors involved in reporting these two levels of education are insufficient to cancel the differences.

Information on *actors* is also unsatisfactory. No actor listed in the 1899 directory reported education beyond the secondary school level.[14] This is almost certainly an understatement of such education, although the youthful beginnings of outstanding professionals of the stage formerly was as proverbial as the cleavage between this vocation and that of the rest of society. In 1934 only 8.7 per cent. of persons prominent in the theatrical and motion picture world reported college degrees, but almost 20 per cent. more had attended college. The total for college education was lower for this vocation than for any other occupation except art. Nearly 42 per cent. had only a common school education, the highest percentage of any occupation. The increased importance of college theatrical groups, however, may be expected to have an effect on the educational status of the theatrical leaders of the future. On the other hand, unless the theatrical profession changes sufficiently for persons who have never acted professionally prior to the age of completing education to avoid serious handicaps to their careers, the increase of college-trained theatrical leaders will probably not be great.

At the present time no data are available on trends in education of prominent *architects*. The 1934 data did not differentiate this group. Of those names first added to "Who's Who in America" in 1928, 82.1 per cent. had attended college, 53.6 per cent. being graduates.[15]

Scientific, Medical and Technical Vocations

For *scientific men* the degree of education is even greater on the average than for literary men. And this had been true for a long time. De Candolle, one of the earliest students of eminent men, but focussing his attention mainly on scientists, mentioned education as one of the chief factors in their production.[16] And almost all "starred" American men of science a generation ago were highly educated, generally attending the world's best universities and taking advanced degrees in them.[17] In spite of this, there has apparently been a tendency toward higher educational levels for "Who's Who in America" scientists in more recent years. At the turn of the century only 55 per cent. of the scientific group reported college training,[18] in contrast with figures of 92.9 per cent. for those first listed in 1928,[19] and 89.2 per cent. for all scientists included in the 1934 edition.[20]

Evidence on education of eminent *engineers* also shows a definite trend toward increased education. In 1899 only 37 per cent. of the engineers listed

12 Dexter, *op. cit.*, p. 247.

13 "Who's Who in America," 1910–11, p. xxv.

14 Dexter, *op. cit.*, p. 247.

15 "Who's Who in America," 1930–31, p. 26.

16 Alphonse de Candolle, "Histoire des Sciences et des Savants depuis deux Siècles," Second Edition, Geneva-Basle, 1885, 410–411.

17 J. M. Cattell, "A Further Statistical Study of American Men of Science," *Science*, n.s., 32: 643. At this time 92 per cent. held baccalaureate degrees and 75 per cent. doctorate degrees in philosophy or science. Nevertheless, Simon Newcomb and William James, the most eminent American scientists in 1903, had no regular college or university education, Cattell, *Idem.*

18 Dexter, *op. cit.*, p. 247.

19 "Who's Who in America," 1930–31, p. 26.

20 Based on a combination of data for geologists, chemists and other scientists, taken from Table I.

in "Who's Who in America" were college graduates,[21] compared with 72.0 per cent. college attendance and 55.5 per cent. college graduation for persons in technical engineering occupations listed in "Who's Who in America" 1910–11.[22] A larger percentage was disclosed by a study of 730 engineers chosen as eminent by virtue of holding office, being a member of a standing committee, or being a representative of one of four leading engineering societies during the years 1915–1919 inclusive: The American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Institute of Mining and Metallurgical Engineers. Of the 730 men, 79.5 per cent. had the equivalent of a college diploma, 4.8 per cent. had attended college without graduation, and 15.8 per cent. had only secondary school training. Highest leadership in the electrical and mining and metallurgical fields was more nearly closed to the person without college training than was highest leadership in the civil and mechanical engineering groups. Only about 11 per cent. of the former leaders had no more than a secondary education, compared with almost 20 per cent. for the latter two groups. Of the engineers in this list, 315 were also in "Who's Who in America."[23] And of these 85.4 per cent. were college graduates and 5.7 per cent. more had attended college without graduation.

There has been no further significant change in the education of the engineering group. In 1934, as a matter of fact, those with college degrees constituted a smaller proportion of the total than was disclosed in Walters' "Who's Who in America" group. The corresponding figure for the engineers first admitted to the list in 1928 was 92.1 per cent.[24]

21 Dexter, *op. cit.*, p. 247.

22 "Who's Who in America," 1910–11, p. xxv.

23 Raymond Walters, *School and Society*, 13: 322–329, 1921.

24 "Who's Who in America," 1930–31, p. 26.

Physicians and surgeons included in the 1934 list reflect the high educational standards of the profession. "Who's Who in America" did not include any medical leader who had not a doctor of medicine degree. This was the only vocational group in the entire list that was 100 per cent. college trained. In 1899 the record was much poorer. In that year only 42 per cent. reported college graduation,[25] compared with 71.8 per cent. college attendance and 54.4 per cent. graduation in 1910.[26] Data on starred scientists in the field of medicine from the 1903 and 1910 studies of Cattell show a much higher percentage of persons with college degrees than for the medical men in "Who's Who in America," 1910–11. A total of 94.1 per cent. of the 238 cases had doctor of medicine degrees,[27] and probably a number of others had attended college, although it must be recognized that holding the M.D. degree does not signify previous baccalaureate degrees for these various lists. Higher degree of eminence, nevertheless, appears to be associated with higher levels of education in the medical group.

Undoubtedly the most powerful factor in the present educational level and in the phenomenal gains registered since 1910 is the prestige and the set of certification standards of the American Medical Association. So important for professional success is such certification that few physicians can practice without its full sanction and no person can become nationally prominent in medicine without this sanction. As certification has become based on progressively rising educational standards, a doctor's degree from an accredited medical school has in late years become increasingly as prerequisite for professional tolerance as it has even longer been for leadership in the profession. It is not as a medical man that a person without a medical degree can now

25 Dexter, *op. cit.*, p. 247.

26 "Who's Who in America," 1910–11, p. xxv.

27 R. M. Pearce, *Science*, 42: 264–278, 1915.

attain the recognition implied by inclusion in "Who's Who in America."

Inventors may also be discussed here, although they are neither scientists nor engineers. Of inventors listed in the 1899 "Who's Who in America" 23 per cent. reported college degrees.[28] Later tabulations published in the directory do not, however, report on this group separately from the other miscellaneous vocations. A recent study by Winston of American inventors eminent enough for inclusion in the "Dictionary of American Biography" reveals that only 16.7 per cent. held college degrees. Although comparisons are of doubtful validity, such data suggest a slight gain in educational status for inventors prior to 1900.[29]

Religion, Education and Law

The *clergymen* listed in "Who's Who in America" have consistently reported a high level of education. In 1899, 52.4 per cent. had college degrees.[30] In 1910 the corresponding figure was 84.0 per cent.[31] and in 1934 it was 88.5 per cent. This group is closely similar to scientists in the level of education reached and somewhat inferior to medical men in the trend toward advanced levels of education.

Educational leaders surpassed all other groups in level of education in 1899, at which time 72 per cent. reported college graduation.[32] The superiority of their educational status is not surprising in view of the fact that the occupational affiliations of most of these leaders was at the level of college and university education. For this reason only some other educational level attained would be incomprehensible and require detailed comment. However, comment is required when we note the failure of the average educational status of the group to keep pace with that of the medical men in 1934. Compared with a perfect record for the latter, 1.3 per cent. of the educators did not report any college education, and another 1.8 per cent. reported college attendance without graduation.[33] Failure to keep pace with medical leaders is mainly due to the more stringent prerequisites for success in the medical profession. It is still possible for a few persons with little formal training to rise to eminence in college and university education in this country just as it always has been. But the number who do so is so small that the educational group now is second in educational background only to the medical profession.

Persons prominent in the *legal profession* are slightly inferior in college education to those in religion and education. In 1899 about 46 per cent. were college graduates,[34] compared with 53.8 per cent. in 1910.[35] In 1934 the corresponding figure was 82.3 per cent. The gain reflects the increased importance of college education in the country as a whole. The great increase in college graduates is also affected by rising standards of law schools during the period. The requirements for certification to practice law have become somewhat higher, too. The fact remains, however, that some people can rise to eminence in this profession by attending secondary school and short law courses, and by private study, always, to

28 Dexter, *op. cit.*, p. 247.

29 Sanford Winston, *American Sociological Review*, 2: 846, 1937.

30 Dexter, *op. cit.*, p. 247.

31 "Who's Who in America," 1910–11, p. xxv.

32 Dexter, *op. cit.*, p. 247. Data on educators and college professors were combined.

33 The figures for first admissions to "Who's Who in America," 1928–29, were lower for college graduation: 96.3 per cent. ("Who's Who in America," 1930–31, p. 26). The same percentage of college attendance (99) was revealed by this source as by a study of 1,552 persons, selected by a method of random sampling from "Who's Who in Education," 1932 (H. M. White, "A Study Based on Biographies of Leaders in Education," *M.A. Thesis*, University of Kansas, 1934, p. 33).

34 Dexter, *op. cit.*, p. 247.

35 "Who's Who in America," 1910–11, p. xxv.

be sure, followed by passing the examinations for certification. In 1910 more lawyers than artists were "self-educated," as many started off with private instruction, as was true of any other group, and far more were educated only in preliminary school. And in 1934 common school education was more prevalent for lawyers than for any other "learned profession." The vocation of law, therefore, exhibits the general trend toward higher education without that education being prerequisite for a successful career. In turn, the chances for eminence of the holder of a college degree have apparently increased while those who do not hold degrees are at an increasing disadvantage.

Public Service

Public officials, although lagging behind the learned professions in formal educational background, bear out the same general trend of increasing college education. Dexter's study of the 1899 "Who's Who in America" group revealed that only 22 per cent. of the United States congressmen and statesmen were college graduates,[36] compared with 59.2 per cent. in 1934. An additional 19 per cent. had attended college. The total and the graduate figures were much below those for lawyers, in spite of the fact that most of the highest public officials have legal training. The discrepancy is to be explained mainly by our political system which makes it possible for persons with a minimum of education but a maximum of political power or prestige to be selected to make and administer the laws of cities, states and the nation.

All *army officers* above the rank of colonel *and navy officers* above the rank of captain are automatically listed in "Who's Who in America." These men exhibit the general educational trend quite as strikingly as any other group, although it might be supposed that the general trend would not have affected them. In 1899, 55 per cent. were listed as having education equivalent to that obtained in colleges and universities.[37] This figure placed the military group among the leaders, a position it has maintained. In 1934 the percentage having education approximating college graduation was 95.2 of all those reporting adequate educational data. Even when allowance is made for possible differences between the meaning of "college education" of the 1899 study and "equivalent to a college education" in 1934 there certainly has been a rise in percentage with high formal education. This group at all times has taken its place with the most highly educated classes, being surpassed in 1934 in percentage of graduates only by medicine, education and chemistry, and in total college education by medicine, education, religion, geology and chemistry.

Business Men and Agriculturists

Business and industrial leaders exhibit an entirely different picture from that of most of the groups mentioned previously. They most nearly resemble public officials, journalists and authors. In 1899 only 12 per cent. of business men and 18 per cent. of financiers were college graduates.[38] In 1934 the total college group constituted 67.7 per cent. (graduates 49.8 per cent.) of the business and industrial leaders listed in "Who's Who in America." This impressive gain has been accompanied by an expansion of accredited business school enrolment as well as by the general increase in college attendance.

Although not strictly comparable to these data, it is interesting to note that the college percentage of graduates among American millionaires reported by Sorokin in 1925 was 54, and thus surpassed the "Who's Who in America"

[36] Dexter, *op. cit.*, p. 251.

[37] Dexter, *op. cit.*, p. 247.

[38] *Ibid.*

figures,[39] as would be expected in view of the assumption that the most eminent persons of an occupational group would have more college education, because college education is an advantage in obtaining prominence.

A study by Taussig and Joslyn of several thousand directors of American corporations in 1928 provides a further basis of comparison with the "Who's Who in America" data. Of the whole group 31.9 per cent. were college graduates, and 13.4 per cent. more had attended college, compared with 26.7 per cent. who had not continued their education beyond grammar school.[40] These figures are between the 1899 and 1934 "Who's Who in America" proportions. More significant, however, are figures on education of the subjects by age groups. The percentage of college graduates and those with college education rather consistently decreased as the age of the group increased. Of those men 75 years of age and over only 15.0 per cent. were college graduates and 11.5 per cent. had attended college without graduating. The corresponding figures for those from 45 to 49 years of age were 34.1 and 13.5 per cent. compared with figures of 42.1 and 23.7 per cent. for those under 30 years of age.[41]

No evidence on trends in the education of prominent *agriculturists* is available at this time, although the high status of this group in 1934 (55.3 per cent. college graduates) suggests an increase in higher education in recent decades. Collateral evidence is not of much assistance here, although various studies have been made. It has been found, for example, that a large number of "agricultural" leaders, including research workers and teachers in the field, directors of extension, and of experiment stations, editors of farm publications, managers of farm organizations and government officials and farm operators listed in *Rus*, 1925, were almost uniformly college trained. Only 4.1 per cent. reported no college education, 88.8 per cent. were graduates of colleges and 7.1 per cent. had attended without graduating.[42] However, this group is so heterogeneous, and includes so many people who have been included in other occupational groups in "Who's Who in America" data that the two kinds of information are not exactly comparable. The same thing is true of the group of 383 Master Farmers studied in 1930, of whom only 14.3 per cent. were college graduates, and only 27.6 per cent. had attended more than one year.[43] Since the years of study were not far different in these investigations, they appear to show a complete range of inclusion from true farmers (master farmers) to a group consisting of proportionately few actual farmers (leaders from *Rus*). The "Who's Who in America" group were more equally balanced, although actually including fewer farmers than the master farmer study. If this characterization is correct, the master farmer study is the only one that reveals the farm operator's educational status at all accurately. The percentage of college-trained persons in this group is small but still sufficiently large to leave the possibility of a gain in the last generation in the percentage with college education. The growth of university extension and of agricultural college enrolments has been so great that it seems likely that nationally recognized farm owners and operators have been and are on the way to higher educational levels

[39] P. A. Sorokin, *Social Forces*, 3: 637, 1925. Of particular interest is the fact that only 11.7 per cent. of millionaires of "poor" financial status at the beginning of their careers had graduated from college, compared with 42.2 per cent. and 80.4 per cent., respectively, for those with "middle" and "rich" status at the beginning of their careers.

[40] F. W. Taussig and C. S. Joslyn, "American Business Leaders," New York, 1932, p. 162.

[41] *Op. cit.*, p. 164.

[42] P. A. Sorokin, C. C. Zimmerman, *et al.*, *Social Forces*, 7: 40, 1928.

[43] O. Hamer, *University of Iowa Studies in Education*, 6, No. 2, 1930, 120.

just as are or have been all the other groups concerning which we have direct evidence.

By way of summarizing these data on trends a comparison is provided in Table II between the percentages of college graduates by occupations in 1899 and 1934. Occupations which increased in college education at a faster rate than that of the total group, given in the order of their superiority in rate of increase were medicine, technical engineering, business, public office, law, army and navy and religion.[44] The margin of superiority for all these but the first was less than 5 percentage points. The occupations gaining least in percentage of college graduates were art, theater and motion pictures, and publishing.

[44] The percentage for the whole group for 1934 revealed by Table II differs from that of Table I of the former article on education of eminent men. *Cf.* Smith, *op. cit.*, p. 552. The explanation is that the present table includes persons trained in art and music schools, while the former article eliminates them for purposes of strict comparability of various "Who's Who in America" statistical tabulations.

These differences in rate of increase are not as revealing as an index of the percentage gain which the actual gain from 1899 to 1934 represents of the percentage of college graduates in 1899. When this method of comparison is employed the outstanding group is seen to be business leaders, followed in order by musicians, public officials, doctors and technical engineers, all of which groups surpassed the average for the whole list.

Even this measure is not the most satisfactory indication of improvement in educational status, as measured by college graduation, however, because only in occupations of less than 50 per cent. college education in 1899 could there have been more than a 100 per cent. gain. Some measurement of the ratio of percentage gain to the amount of possible gain is indispensable if we are to have any clear basis for understanding the changes. Column 5 of Table II presents such an index. And here it is seen that medicine made the greatest possible gain, 100 per cent., followed closely by education which had lagged in both other

TABLE II

CHANGES IN THE PERCENTAGES OF ENTRIES IN "WHO'S WHO IN AMERICA" REPORTING COLLEGE GRADUATION, 1899–1934

Occupation	Percentage 1899 Col. 1[a]	Percentage 1934 Col. 2[b]	Amount of gain in percentage points (Col. 2 less Col. 1) Col. 3	Index of percentage gain $\frac{(\text{Col. } 3 \times 100)}{(\text{Col. } 1)}$ Col. 4	Percentage gain of possible gain $\frac{(\text{Col. } 3 \times 100)}{(100 - \text{Col. } 1)}$ Col. 5
Authorship	27	50.9	23.9	89	33
Journalism	33	48.6	15.6	47	23
Art	8	8.5	.5	6	0.6
Music	6	21.3	15.3	255	16
Theater and motion pictures	0	8.7	8.7	∞	9
Science	55	89.0	34.0	62	76
Technical engineering	37	76.9	39.9	108	63
Medicine	42	100.0	58.0	138	100
Religion	53	88.5	35.5	67	76
Education	72	96.9	24.9	35	89
Law	46	82.3	36.3	79	67
Public office	22	59.2	37.2	169	48
Army and Navy	55	91.1	36.1	66	80
Business	12	49.8	37.8	315	43
Total	**37.2**[c]	**72.7**	**35.2**	**95**	**56**

[a] Dexter, *op. cit.*, p. 247. Apparently these percentages are based on all persons in each occupation, while the 1934 data eliminate those reporting no educational information. Consequently, Dexter's percentages are probably understatements.

[b] Based on "Who's Who in America," 1936–37, pp. 2706, 2708.

[c] Dexter did not include educational information on all groups, so that this figure is tentative and probably an understatement when compared with the 1934 college-trained group.

measures of improvement, mainly because its original position was so very favorable. The army and navy, science and religion, law and technical engineering made better than average showings, compared with business, music and public office, which showed up so well in percentage gain but achieved less than half of their possible gain. The arts made the poorest showing, with art the greatest laggard of all, partly because of the ambiguity of the term "art education," and the inconsistency in the statistical treatment in different analyses.

Education and Chances for Prominence by Occupation

The comments made in the last few paragraphs have left to one side the question of the actual contribution of college graduation to potential leaders in these fields of endeavor. Statistical errors have been pointed out and the importance of standards and accrediting agencies have been reviewed. Now it will be of advantage to consider the contributions of college education through differential chances provided by it for eminence and the precise way in which it aids the potential leader.

Evidence that college education is a definite aid to eminence in a field of activity is satisfactory only when there can be no further question of that aid, that is, when other possible interpretations of the facts have been found wanting. This rarely is possible to do, because of the inability to discover or create instances in which each condition and all combinations of conditions can be inserted or eliminated from the pattern of eminence causation. In the absence of this completely satisfactory method, it is still theoretically possible, however, to consider the relative chances for eminence in each field of endeavor possessed by persons with different sorts of educational background. In another place information of this sort, obtained for the whole eminent group, revealed great advantages for the college-trained person.[45] Such a method requires knowledge of the educational background of the eminent persons in each field of eminence, and the educational background of the total persons of a comparable age group in the general population in each field represented among the prominent people under consideration. With this information available it would then be possible to compute the ratio of persons in "Who's Who in America" engaged in each field of activity and with a certain educational background to the total living persons of a comparable age group and educational background in the whole country. Differentials in the ratios for persons of different educational backgrounds would reveal the advantages and disadvantages of each sort of educational background for eminence.

Available information is not sufficient, however, to enable us to make such analyses. The educational background of persons engaged in various occupations in the United States is not known and can not at present be accurately inferred, so that none of the fundamental ratios necessary in analysis in terms of chances for eminence can be computed. This statement is true, in spite of a few attempts to state in numerical terms the advantages of college education for eminence in certain fields. Clarke states that college-trained literary personages had "several hundred times" as many chances for recognition as those not so trained,[46] but no statistical evidence is given in support of such a conclusion. Dexter made a similar attempt for various occupational groups, and concluded that the chances for eminence of persons with college degrees ranged from about 6 to 1 for medical men to 2 to 1 for lawyers and judges.[47] These figures, based

[45] Smith, *op. cit.*, 557.
[46] Clarke, *op. cit.*, p. 68.
[47] Dexter, *op. cit.*, pp. 249–251.

on the assumption that the previous education reported by entrants of professional schools is closely comparable to the figure for the corresponding professions in the whole country, are obviously not accurate enough for differentiation among various occupations. Hamer reported that about 5 times as many master farmers had attended high school and about 6 times as many had attended college as Iowa farmers in general.[48] This statement also makes the assumption that Iowa data are typical of data for the part of the United States contributing to the group of master farmers, which is obviously of little use for occupational comparisons. All that these three statements reveal is that an advantage is enjoyed by the college-trained man in attaining prominence, a fact which is already well known.

It is not possible at this time to improve materially on these efforts. But it seems likely that the advantage of the college-trained man is much less in some professional than in most of the non-professional vocations. For example, in the field of medicine, although all the "Who's Who in America" group in 1934 were college graduates, the advantage of such persons in chances for eminence over those without college degrees can not be as great as for some vocations, because the prerequisites for medical certification tend to eliminate the non-graduate not only from the eminent list, but even from inclusion in the occupation. The same thing is true of the law, engineering and the sciences, and to a certain extent of education and religion.

At the other extreme, agriculture greatly favors the college-trained man, because of the overwhelming proportion of farmers without college education, compared with the rather large percentage of the "Who's Who in America" agricultural group with college degrees. This remains true, although few of the agriculturists of this list actually operate farms or otherwise engage in farm labor. Business and industry are also in the group which is aided by education, because of the many millions of poorly educated persons engaged in such vocations. Near the extreme agriculturists and business men is also to be found the military group. The rank and file of soldiers and sailors have little education, while those men of highest rank and greatest prominence are predominantly graduates of the four-year government military and naval academies.

Contributions of Education to Eminence

From what has been said above and in a former analysis of the contributions of formal education to eminence,[49] it is apparent that the possession of a high degree of formal education is not sufficient to demonstrate that the education contributed to the attainment of the recognition. In the first place, it is possible that in each vocation selective factors explain the correlation of education with eminence. And in the second place, a high level of formal education may be prerequisite to a career in an occupation, the education contributing little or nothing in itself to ultimate recognition. The use of the college degree as a prerequsite for pursuing a vocation is, on the whole, a much-deplored shortcoming of our civilization. In numerous cases societal pressure is such that the degree, rather than the techniques and education, is the focus of attention, and in not a few instances it is necessary for the student to consider carefully whether the formal aspects of the advanced degree will not cost him more dearly than the worth of the degree will be in obtaining a position where his interests in teaching or creative writing or theatrical studies may then be followed. The confusion arising from the factors of selection and the action of

[48] Hamer, *op. cit.*, p. 66.

[49] Smith, *op. cit.*, pp. 558–560.

education as a prerequisite, together with the other difficulties of determining the extent of the dependence of variables, literally makes it impossible to conclude that a person in a vocation with almost universal formal education at a certain level is aided more by formal education than the one in a vocation few of whose members have attained that level.

The difficulties of determining the reason for the correlation of high degree of formal education and eminence that exist for eminent men as an undifferentiated population group are multiplied in proportion to the differentiation of vocations. The best that can be done now is to make a few suggestions concerning the reasons for the formal education of the sort reported for each occupation in Table I, recognizing always that the most superior persons yet may make the greatest achievements without specific degrees of formal education, although they may require the highest order of genius in order to make such achievements. For this purpose the existence of formal college education for each vocation may be considered, as well as the precise contribution of that education in terms of opportunity to obtain technical knowledge, general prestige, entrée to the circle of leaders in the field, shortening of time required to learn the techniques of the vocation and companionship with other students having the same vocational interests.

In the various artistic fields the most outstanding implication of existing knowledge is the relatively small opportunity that existed for college training in such vocations a generation ago, at which time, on the average, the current eminent personages were preparing for their careers. Authorship is different from the other artistic vocations in this respect, because it is the one most definitely aided by college education. The special techniques of these vocations, even of authorship, however, generally had to be obtained apart from and in addition to the college study. And where facilities for training in these techniques were available in the college it was often true that entrée to actual leaders in the various fields was not provided, and the general prestige of the institution in an artistic direction was of little value. It is highly unlikely that the techniques of art were as well taught in any of the colleges and universities a generation ago as outside of them in special schools or private studios. Consequently, it is reasonable to conclude that the small percentage of college education for the artistic groups represents comparative lack of advantage or actual handicaps of such education at the time to careers in such fields. Even such items as companionship with other students and the existence of leisure time for study, which all group education supposedly provides, were rarely advantageous to persons of artistic interests who were seeking baccalaureate degrees, since ordinary student interests are not in artistic achievement, and leisure undirected toward one's major interests may not only weaken them somewhat but may even establish strong habits of use of leisure time in ways that contribute nothing to achievement or recognition, but are nonetheless with difficulty broken. It is even probable that the college degree a generation ago has to its discredit the prevention of development of considerably more potential leaders along artistic lines than it actually aided.

The scientific and technical vocations and the professions of religion, education and law have been most clearly aided by the institutions of higher education. To be sure, part of the correlation of success in these vocations with college training is due to the fact that the degree is practically prerequisite to success, but the system of higher education is particularly useful to persons in these fields. Universities, throughout the centuries of their history, have been devoted mainly toward

preparation for such occupations. They have established favorable connections with the non-university worlds of these vocations. They have such prestige that the most able persons in these fields often are attracted to their faculties. Where there is such a close contact between the university and non-university worlds the technical side of university education is strengthened and its usefulness to the student is correspondingly enhanced. Contact with leaders in each vocation is provided by the foremost educational institutions, and the student's general prestige is likewise increased. To these advantages may be added the undoubted advantages of shortening the length of time required to learn the techniques of the vocation and companionship with select persons engaged in studying the same problems.

The vocations of public service, and business and industry, including journalism and agriculture, more nearly resemble the artistic vocations than the professions in the contribution made to them by formal education. College training is not even yet prerequisite to success in any of these activities. Colleges, at the time the present national leaders in these fields were completing their education, were not organized to provide well-rounded technical training in government service, or in most business and industry. But the system of military education was as highly organized as any of the professions, even to the point of establishing graduation from the United States Military Academy and the United States Naval Academy as a virtual prerequisite for highest recognition in these vocations. Not only have these practical vocations of government, industry and business lagged in the development of transmissible techniques, but colleges and universities are able to give but little general prestige to their students entering these fields. Similarly, the educational institutions as a rule are unable to attract business and political leaders to their faculties so as to provide contact for their students to the leaders of these fields. The so-called democratic political and economic system is largely responsible for the lack of articulation of the educational system with the political and economic system. A man's political contacts in this country exist only so long as he is active in politics and has political influence. Professional educators have been suspicious of political figures and political leaders generally despise or deprecate the educator, with the result that only in rare and notable instances is the gap bridged. However, the development of a permanent career class trained in government and the increased use of academic experts by all political groups indicate that the institutions of government and education will eventually be brought into synchronization in the United States, and not only by means of the government entirely absorbing the activities of the university faculty members for months or years during which the university claims are merely formal, and after which the political contributions and contacts of the faculty member no longer continue.

University colleges of business, like colleges of fine arts, are rather recent in development and affect the "Who's Who in America" data but slightly. The percentage of college graduates in business and industry, revealed by the present analysis as comparable to that of authorship, like it, is explained more by incidental factors than by direct contribution of education to eminence. Younger representatives of wealthy families who enter business and industry are usually college trained. And of the other leaders in business and industry many have attained prominence because of ability and industry rather than as a result of the college training. If these groups could be eliminated from the statistics reported above, the resulting contribution of col-

lege education to business leadership would probably be only slightly more than that of the artistic vocations.

In summary, it may be pointed out that the percentages of recognized persons without formal education in the various vocational groups may also be thought of as an indication of the possibility for eminence in each vocation even when the person has no education. Only in medicine was it true in 1934 that every nationally recognized person reported college graduation. Prior to 1934, under the most favorable conditions, closely paralleling in advantages those of formal education, Americans might have obtained national recognition in every field of eminence but medicine under private tuition. Such an accomplishment has become increasingly difficult in recent generations, but until the present time has not been impossible. So long as the various advantages deriving from formal education can be obtained in any other way formal education is not absolutely necessary. Only in medicine, and in that vocation only because of the high standards and firmness of control by the accrediting agencies, is it impossible to attain the highest recognition without formal education of high collegiate level.

But consideration makes us realize that if the recent trends continue the difficulties of recognition without a high level of formal education will increase in all fields in the future, and that in several of them college graduation may eventually become prerequisite for leadership. It is obvious, then, that considerable emphasis should be placed on the advantages of college education for eminence in most fields, notwithstanding the arguments of those who explain the correlation of college education and eminence on the principle of selection rather than the contributions of education.[50] Somewhere between the extreme claims of the educator and the selectionist lies the true explanation of the correlation, which explanation experience teaches us is more complex than simple and more influenced by the cultural situation and by processes of interaction between persons who achieve and those who evaluate their achievements than is usually realized.

[50] This point of view is discussed by P. A. Sorokin in "Contemporary Sociological Theories," New York, 1928, Chapter V, and "Social Mobility," New York, 1927, p. 187 *ff*.

THE CLAIM OF THE SOCIAL SCIENCES

We are living in a world that threatens to brush aside everything that intelligence stands for. Two great wars and the prospect of more; over half the population of the earth caught in this maelstrom of destruction; ten years of depression with millions everywhere still without employment; confusion over issues and values that leaves men frustrated and uncertain—it is little wonder that the temptation is to forsake reason and resort to force.

One of the difficulties is that force seems to be such an easy answer. It appears to cut through the complexity and confusion without the necessity of the severe intellectual effort and discipline involved in creating any effective alternative. The real tragedy is not that so many men in the world believe in force as a method of social organization as that so many who reject force as an ideal surrender to it in practice because there seems to be nothing else to do.

But force in the end always defeats itself. In the long run it solves nothing and answers nothing. It brings us no step nearer the prospect of the "great society" which science and culture have revealed. If the world of the future is a more promising habitation for mankind it will be only as a result of the persistent application not of force but of intelligence against the things that now thwart our hopes.—*Raymond B. Fosdick, President of the Rockefeller Foundation, from "A Review for 1939."*

BOOKS ON SCIENCE FOR LAYMEN

SAMPLES OF SCIENCE[1]

THE intellect of a nation is stratified. At the top we find the university professors and leaders in law, science, business and politics; lower down a layer of college graduates who have had the benefit of a liberal education; still lower a thicker layer of intelligent but inadequately educated office, factory and farm workers; at the very bottom a dense magma of humanity which is more emotional than intelligent, more interested in being entertained than informed. Magazine and newspaper publishers hew out circulations in each stratum and in the process make discoveries about human interests. When the tabloid was invented during the World War for the sole purpose of enabling a Chicago publisher to rid himself of excess profits it was supposed that what was still called "yellow journalism" had reached rock-bottom and that below it there was unexploitable mental incompetence. The tabloid in question proved that in the depths there is still something that can read and write and respond to the raw facts of murder and gossip and especially to situations that are technically known as "he and she" news stories. Is this the pre-Cambrian rock-bottom of humanity? It seems not. The psychologists have plumbed the vast radio audience and found that it must be appealed to by devices utterly different from those resorted to even by tabloid journalists who rarely use words of more than three syllables.

All this is of importance in considering "Excursions in Science" because the chapters of which it is composed are radio talks which should be judged in the light of these psychological revelations.

[1] *Excursions in Science.* Edited by Neil B. Reynolds and Ellis L. Manning. xiii + 307 pp. $2.50. 1939. Whittlesey House (McGraw-Hill Book Company).

It is very plain that the authors of the talks were utterly unaware of the different techniques that must be invoked to drill down to the lowermost human strata. So we have some thirty-seven little essays which, though especially prepared for delivery by radio, were written just as if they were contributions to a newspaper or a magazine. Though the authors took the utmost pains to express themselves simply and clearly it is highly questionable whether they were understood by two per cent. of their hearers. It would be hard even for Sir James Jeans to compete with Charlie McCarthy. Thirty-seven writers who are research men and therefore accustomed to analyze problems never troubled to find out how a radio audience should be addressed, but assumed that what is acceptable in the popular press is acceptable from the loudspeaker. As radio talks they are not a success. As literary products, they are competent thumbnail sketches of the recent work done in surface chemistry (Langmuir), atomic physics (Rochow, Ridenour), lightning (McEachron), thermometry (Elder), fluorescence (Koller, Fonda), solar physics (Hewlett), microchemistry (Liebhafsky), seismology (Smith), probabilities (Benford), electronics (McArthur, Johnson), genetics (Haskins), meteorology (Blodgett).

Most of the authors discuss work in their own research fields and hence with the expected accuracy and authority. There is no attempt at romantic treatment. Particularly good is Neil B. Reynolds' discussion of science and superstition and his picture of what the scientific method can do in archeology. McEachron has presented an effective account of the recent work done in lightning research. But most of the men are not literary artists. The fingers of a

copy editor itch to hack away the redundant "pens" and "pencils" in this passage from Dr. Langmuir's otherwise excellent article on "Simple Experiments in Science":

> The pencil is a round one, and the pen has a considerable larger diameter than the pencil. If I sit down at a table and place the pencil across the pen I find that I can balance the pencil on the pen by carefully moving the pencil back and forth until the center of gravity comes just over the point at which it touches the pen. When I balance the pencil in this way, and then displace it a little by pushing one end down, the pencil, instead of falling off the pen, oscillates back and forth with a definite period of oscillation, like a pendulum.

It is good to see that when they put their minds to it professional scientists can write on science in a way that such ordinary mortals as lawyers, corporation presidents and congressmen can understand. This reviewer hopes that the editors will repeat their interesting experiment, but that when they do the contributors will soar and tell us more of the implications of research.

WALDEMAR KAEMPFFERT

ARE MENTAL DISORDERS INCREASING?[1]

IT is an astonishing fact that ever since the first public mental hospital was established in this country in 1773, states have built further hospitals and additions thereto in a rather hit-or-miss manner, conscious only of the fact that more demands for beds were being made, while at the same time no really informative statistics were being collected as a guide. Any business which attempted to run on a similar inspirational basis would long since have gone into bankruptcy!

It remained for the genius of Dr. George Milton Kline, Commissioner of Mental Diseases for Massachusetts from 1916 until his untimely death in 1933, and a giant among hospital administrators, to interest the Rockefeller Foundation in subsidizing a thorough-going study of the epidemiological aspects of mental disorder. This work, carried on since 1928 under the supervision of Dr. Dayton, a thoroughly experienced psychiatrist and an outstanding statistician, is now bearing fruit in the form of this volume, a study of 89,190 admissions to the mental hospitals of Massachusetts during the period 1917–1933. Here, for the first time, some facts are presented which had only been guessed before, and other facts which completely refute long-cherished notions. During the administration of Dr. Kline (the period covered by these statistics) Massachusetts had an excellent state hospital system, reasonably adequate in capacity, a public which had confidence in the institutions and laws which facilitated admission to the hospitals with a minimum of formality. There were, in short, no artificial barriers to color the statistics such as exist in some states (such as rigid commitment laws, serious overcrowding, holding of mental patients in jail, etc.).

The volume is so tightly packed with information that it is difficult to give an abstract: In general, it may be said that through the use of modern statistical devices (and the necessary aid of mechanical sorting) such factors as age, nativity, marital status, use of alcohol and diagnosis are studied year by year and with relation to each other. Such a thorough study of so large a number can not and does not fail to yield information which is of the highest significance and validity.

Dayton shows that the so-called increase in average length of life is largely due to the decrease in infant mortality and in various preventable diseases, whereas the expectation of life for a person over fifty is actually decreasing. Similarly, the admission rates for persons under 40 are falling, whereas those

[1] *New Facts on Mental Disorders.* By Neil A. Dayton. xxxiv + 486 pp. $4.50. C C Thomas Publishing Company.

for persons over 40 have shown a decided trend upward in the 16-year period. This is generally true for readmissions as well as for first admissions. Indeed, the age incidence of mental disease follows the death rates surprisingly closely. Taking the 10–19-year group as unity for first admissions (per 100,000), we find the (male) 30–39-year rate to be 4.6, the 60–69 to be 7.2, and the 80–89 to be 19.9 (females slightly lower)! In other words, far from being an affliction of early life, mental disorder is essentially a disease of old age. Furthermore, men are shown to wear out faster; the rates throughout life are higher for men than women. The fact that mental disorders are decreasing below the age of 40 is corroborative of the belief that the child guidance movement, in which Massachusetts was a pioneer, is showing its preventive effects on the development of mental disease.

As for nativity, the highest admission rates are found in the foreign-born, the next lower in the native-born of foreign parentage, the next in the native-born of mixed parentage, and the lowest in the native-born of native parentage, but—the increase in the rates of the last-named group has gone up so rapidly in 16 years while the others remain almost stationary that the tendency seems to be toward an almost uniform rate.

Some evidence for the protective value of marriage (especially for men) is adduced by a study of the figures. The lowest rates of incidence are found among the married, with an ascent in order through the widowed and the single to the divorced. Interestingly, the incidence for single men is 60 per cent. higher than for single women, and for widowed and divorced men is 35 to 40 per cent. higher than for women of the same marital status. In other words, the breaking up of the home is bad for either sex, but works greater hardship on the male.

The findings as to use of alcohol appear to indicate that since 1924 (the high point), despite unemployment and depression, there has been a decrease in alcoholism among persons admitted to mental hospitals. Prohibition seems to have had a more lasting effect on females, the group who needed it the least (34 per cent. of the males as against 74 per cent. of the females were reported as abstinent).

The most significant chapter, perhaps, is the final one, entitled "Are Mental Disorders Increasing?" The author proves a fact which has been heretofore almost entirely overlooked, namely, that the increase in mental hospital population, about which there has been so much popular clamor, is due only in small measure (about one sixth) to the increase in admissions. The fact is that the increase is due to the piling-up of long-residence patients, together with the fact that the average stay in hospital was found by the author to have increased from 8.9 years in 1929 to 9.7 years in 1937. Some idea of the length of residence of some types of cases may be gathered from the fact that at the end of 1937 it was found that one third of the patients in the Massachusetts state hospitals had been in residence 10 years or more, and 14 per cent. 20 years or more. Indeed, nearly 0.7 per cent. had been patients for over 40 years!

The author concludes the chapter with the pregnant statement:

> Here we have two implications (1) that society has been unable to absorb recovered patients ready for discharge to as great an extent in recent years as in past years and (2), that changes are taking place in the recoverability of existing mental disorders, which necessitate a longer period of hospital residence for purposes of treatment. Either question offers a major challenge to the psychiatrist, to the administrator and to society as a whole.

The volume is probably the most significant contribution to our knowledge of the statistics of mental disorder ever

published. It is to be hoped that the research of Dr. Dayton will be continued, to furnish further fruitful volumes. In the meantime, psychiatrists, legislators, sociologists and thinking citizens in general are greatly in the debt of Dr. Dayton for having thrown much light into places hitherto dark and puzzling.

WINFRED OVERHOLSER
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PRESENT AND FUTURE OF TELEVISION[1]

"THE Victory of Television" presents an interesting account of present accomplishments and future possibilities of television, written for the layman who is interested in what this means of communication has to offer rather than in the principles of picture transmission. The first two chapters give a brief, very elementary summary of the history and operation of a modern television system. There follows a description of the technique used in the studio production of visual programs, with a mention of the problems of obtaining suitable lighting, sound and scenery effects. A number of ingenious expedients that have been adopted to produce the required illusions are recounted. After discussing at some length the wide range of subjects suitable for television broadcasting, including educational and cultural material as well as features intended solely for entertainment, another, very important phase of the subject is broached, that is, the economic aspects of program production, broadcast maintenance and interlinking networks. The book concludes with a discussion of the unlimited future possibilities of television.

V. K. ZWORYKIN

[1] *The Victory of Television.* By Philip Kerby. Illustrated. x + 120 pp. $1.00. 1939. Harper and Brothers.

SHELL COLLECTOR'S HANDBOOK

THIS handy little book provides a very useful means of identifying shells collected by the average amateur naturalist. The scope of the book is the coast line from Labrador to Cape Hatteras, and while it has been obviously impossible to include all species, a fairly representative selection has been made and practically all the forms most commonly found by the shell collector have been mentioned.

The book is divided into five parts: first, the marine pelecypods or clams in which 48 species are described and illustrated; second, the marine gastropods or snails, including 44 species; third, the fresh-water pelecypods with 24 species; then the fresh-water gastropods with 20 species, and finally the terrestrial gastropods or land snails with 32 species.

Although the marine species included in the book range from Labrador to Cape Hatteras, the reviewer has found the book to be somewhat more useful in determining the shells of the beaches from New Jersey northward than those of the more southern portion of the area covered.

The sections on the land and fresh-water shells should be particularly welcome at the present time. While there are a number of different books available to the amateur naturalist that describe and illustrate the marine shells of different sections of the coast, there has been very little available in non-technical terms on the land and fresh-water mollusks.

There are illustrations of each species described, the majority being adequate for identification purposes. There is also an introduction, a glossary and an index.

HORACE G. RICHARDS

[1] *What Shell Is That?* By Percy A. Morris. 168 figures. x + 198 pp. $2.25. 1939. D. Appleton-Century Company.

THE PROGRESS OF SCIENCE

THE ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES

THE National Academy of Sciences held its seventy-seventh annual meeting on April 22, 23 and 24 at its home in Washington, D. C. At this time of the year the Japanese cherry trees and other plants and shrubs are in blossom and bespeak the passing of winter. Washington is crowded with visitors, eager for a foretaste of spring and its promise of relief from the routine of winter. One hundred and forty members of the academy attended the meetings and thirty-three presented papers at the scientific sessions; fifteen other papers were given by men introduced by members. The distribution of these papers among the sciences was: mathematics, 4; mathematical physics, 2; astrophysics, 2; physics, 7; chemistry, 5; physical chemistry, 3; geology, 2; biophysics, 6; biochemistry, 2; pathology, 2; biology, 3; bacteriology, 2; botany, 6; anthropology, 1; psychology, 1.

The Tuesday afternoon session was set aside, as an experiment, for the presentation of six invited papers from different fields of science on topics of interest to the specialist and to the layman. Dr. G. D. Birkhoff, of Harvard University, spoke on the "Principle of Sufficient Reason," and showed that this principle is intimately connected with what might be termed the Theory of Ambiguity and with the associated mathematical Theory of Groups which has contributed much to the understanding and solution of problems in the physical sciences. Its fruitful application to biological and social theory will probably be made as knowledge in these highly complex fields of thought develops.—Dr. K. K. Darrow, of the Bell Telephone Laboratories, described recent discoveries in the field of nuclear fission due to the entry of a neutron into a massive atom-nucleus, thus producing an internal explosion in which the nucleus is divided into two fragments and an enormous amount of energy is released. Many radioactive bodies are formed, and fresh neutrons are emitted in great quantities, possibly adequate to convert the process, once initiated, into a self-perpetuating one under realizable conditions.—Dr. W. H. Bucher, of the University of Cincinnati, discussed the origin of submarine valleys on the continental slopes of the North Atlantic and suggested that they owe their origin to erosion produced by deep-seated waves of great length set up by landslides and crustal movements accompanying earthquakes or submarine volcanic outbursts. Impinging on the continental shelf, this type of wave motion persists for many hours. Its energy greatly exceeds that of tidal-wave motion and appears to be adequate to accomplish the observed erosion along the margins of the continental shelf.—Dr. D. R. Hoagland, of the University of California at Berkeley, referred to the importance of minute quantities of certain chemical elements, such as boron, copper, zinc, manganese and molybdenum in the growth and metabolism of higher plants. In larger amounts the same metals may have a toxic effect on plant growth; but their presence in extremely small percentages is necessary for both plant and animal growth.—Dr. Roger Adams, of the University of Illinois, discussed the "Chemistry of Marihuana," and described experiments made to isolate the active physiological agent in the resin exuded by the female hemp plant at the time of flowering. By proper extraction of the resin a high-boiling viscous product known as "red oil" is obtained which carries an active principle. Two inert substances, cannabinol and cannabidiol, have thus far been

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obtained, but the active principle has not yet been isolated and identified.—Dr. W. G. MacCallum of Johns Hopkins University spoke on viruses and their part in disease. He emphasized their extreme minuteness; their dependence upon living cells for growth; their action in producing disease and predisposing to secondary bacterial infection; their action in producing antibodies and lifelong immunity, and their fairly specific relation to certain hosts. He referred to recent experiments on the crystallization of a certain virus as a nucleo-protein, perhaps with ferment activity, and alluded to the difficulty of ascertaining the borderline between inanimate and living in virus problems.

The Monday evening public lecture was given by Dr. E. O. Lawrence, of the University of California at Berkeley, on the subject "Bombarding Atoms." For this purpose the cyclotron was devised by Dr. Lawrence, who traced its development during the past decade to the present apparatus capable of projecting neutrons at voltages in excess of 15 million volts. He referred also to the huge cyclotron now in process of construction, with which 100 million volts will be obtained. He illustrated by simple experiments some of the results obtained by use of the cyclotron which is the most important tool now available to students of nuclear physics and possibly also to workers in biophysics and biochemistry. Dr. Alfred Loomis served as test object in one of these experiments.

The average attendance at the sessions in the auditorium was 300 and in the lecture room 200; at the evening lecture 575 persons were present.

On Monday afternoon seventy academy members and guests visited the Library of Congress and its new annex building. The librarian, Dr. Archibald MacLeish, welcomed the group and referred briefly to the purposes and functions of the library as an aid to scientists and scholars. The visitors were shown

the new facilities in the annex for making photostat and microfilm copies of books and newspapers, for printing labels, cards and pamphlets, and for indexing and cataloguing the immense collections of books at the library. The visit was extremely interesting and was appreciated by the visitors.

At the annual dinner on April 23, three medals were presented: The Agassiz Medal for Oceanography was awarded to Frank Rattray Lillie, past president of the Woods Hole Oceanographic Institution, "for his important contributions to the science of oceanography through his promotion of the plan, adopted by the Academy, by which the United States should take part in a world-wide program in oceanography." The presentation address was made by Dr. E. G. Conklin, a member of the committee that recommended the award.

The Public Welfare Medal, from the Marcellus Hartley Fund, was awarded to John Edgar Hoover, director of the Federal Bureau of Investigation, Washington, D. C., "for his application of scientific methods to the problem of crime prevention." The presentation address was made by Dr. Max Mason, a member of the committee that recommended the award.

The Charles Doolittle Walcott Medal and Honorarium were awarded to Dr. A. H. Westergaard, of the Sveriges Geologiska Undersokning, Stockholm, Sweden, "for his eminent researches on the stratigraphy and paleontology of the Cambrian formations of Sweden." The presentation address was made by Dr. C. G. Abbot, a member of the Board of Trustees that recommended the award. The medal was received, on behalf of Dr. Westergaard, by the Minister of Sweden, the Honorable W. Bostrom, for transmission through diplomatic channels.

At its business meeting on Wednesday, April 24, the academy elected the following officers and members:

Foreign Secretary:
- L. J. Henderson, Lawrence professor of chemistry, Harvard University.

Treasurer:
- J. C. Hunsaker, head of the department of mechanical engineering, Massachusetts Institute of Technology.

New Members of the Council:
- S. A. Mitchell, professor of astronomy and director of McCormick Observatory, University of Virginia.
- W. Mansfield Clark, De Lamar professor of physiological chemistry of the School of Medicine, Johns Hopkins University.

DR. JAMES B. MURPHY
MEMBER OF THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH.

- Oswald Veblen, professor of mathematics, Institute for Advanced Study, Princeton.

New Foreign Associates of the Academy:
- Sir Henry Dale, National Institute for Medical Research, Hampstead, England.
- James P. Hill, professor emeritus of embryology, University of London.
- Bernardo A. Houssay, facultad de medicina, Instituto de Fisiologia, Buenos Aires, Argentina.
- Giuseppe Levi, visiting professor, Institute of Pathology, University of Liège, Belgium.

New Members of the Academy:
- Rollin Thomas Chamberlin, professor of geology, University of Chicago.

Carl Ferdinand Cori, professor of pharmacology, School of Medicine, Washington University, St. Louis.

George Washington Corner, professor of anatomy, Strong Memorial Hospital, University of Rochester.

Louis Frederick Fieser, professor of chemistry, Harvard University.

Wendell Mitchell Latimer, professor of chemistry, University of California at Berkeley.

Karl Friederich Meyer, professor of bacteriology and director of the Hooper Foundation, University of California.

James Baumgardner Murphy, member of the Rockefeller Institute for Medical Research.

Isidor Isaac Rabi, professor of physics, Columbia University.

Stephen Walter Ranson, professor of neurology and director of the Neurological Institute, Northwestern University.

William Jacob Robbins, director, New York Botanical Garden.

Richard Edwin Shope, Rockefeller Institute for Medical Research, Princeton, N. J.

William Hay Taliaferro, professor of parasitology, University of Chicago.

Stephen Timoshenko, professor of engineering mechanics, Stanford University.

Ernest Glen Wever, associate professor of psychology, Princeton University.

Claus Hugo Hermann Weyl, professor of mathematics, Institute for Advanced Study, Princeton.

The present membership of the academy is 314 with a membership limit of 350; the number of foreign associates is 43 with a limit of 50.

The autumn meeting will be held this year late in October at the University of Pennsylvania, Philadelphia.

F. E. Wright,
Home Secretary

THE AMERICAN ASSOCIATION MEETS IN SEATTLE

"Oregon Game Trails," written by Francis Parkman nearly a century ago, is the classic story of an adventurous journey from the Missouri River to the far Northwest. This year, from June 17 to June 22, many members of the American Association for the Advancement of Science will assemble for a great scientific meeting in Seattle, Washington, much farther to the northwest than the end of Parkman's famous trails. They will not require months to traverse the plains, pass through the mountains and cross the arid regions. By railroad from Chicago on luxurious air-conditioned trains, in which they may read or recline at ease, it will take them only three days. Or, they can leave New York or Washington by sleeper airplane in the late afternoon and arrive at Seattle between nine and ten o'clock the next morning.

Parkman's long journey was for the purpose of the adventures to be experienced in exploring the unknown; the scientists will visit Seattle for precisely the same reason. Parkman looked on vast areas that had never been seen by the eyes of white men; the scientists will be looking into many and more marvelous regions of which men never even dreamed before our day. Parkman had to depend upon his unaided senses; scientists look into the heavens through giant telescopes, into the essential cells of living organisms with microscopes, into the structure of matter itself with the cyclotron, which will be explained at the meeting by its inventor, Dr. Ernest O. Lawrence. Truly, the adventures of science are the most interesting, important and beneficial that men ever have experienced.

It may well be inquired why scientists should go to Seattle for their meeting. Although it is a great city, delightfully located amid mountains and on an arm of the sea and the seat of an important university, it is far from the great populous areas of our country. The meeting of the association in Seattle is, in part, an expression of the altruism of science. It makes possible a celebration of the achievements in science in a region that

THE SAN JUAN ISLANDS IN PUGET SOUND WITH THE DECEPTION PASS BRIDGE IN THE FOREGROUND AND THE OLYMPIC PENINSULA IN THE BACKGROUND.

not many decades ago was on the very frontier of civilization. It is a tribute to the rapid progress that has been made in education and culture even while a wilderness was being transformed into the home of an organized and stable society.

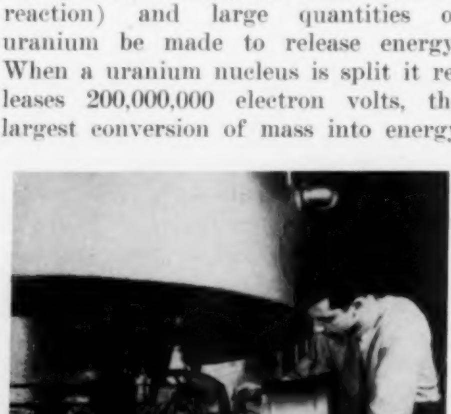
Not all the scientists who will attend the meeting in Seattle will be from the Middle West and the East; indeed, a large majority of them will be from the Pacific Coast and the Mountain States. Nor will their numbers be small, for about 2,600 of the more than 21,000 members of the American Association for the Advancement of Science are residents of the western states. In fact, they are so numerous that they have organized the Pacific Division of the association, which holds its own meetings. The joint meeting at Seattle is the one hundred and sixth meeting of the association and the twenty-fourth meeting of the Pacific Division.

At Seattle twenty-nine other societies will meet with the association. Together they will cover many fields of science—the physical sciences, the biological sciences, psychology and education, anthropology, the medical sciences, agriculture. When Parkman made his famous journey, science consisted of natural philosophy and natural history. Now 171 separate scientific societies and organizations are affiliated with the association. They pay no dues and assume no obligations except to meet with the association when their officers think such joint meetings would advance the interests they were organized to promote. The underlying purpose of all of them is to advance science and civilization.

F. R. MOULTON

PROGRESS IN HARNESSING POWER FROM URANIUM

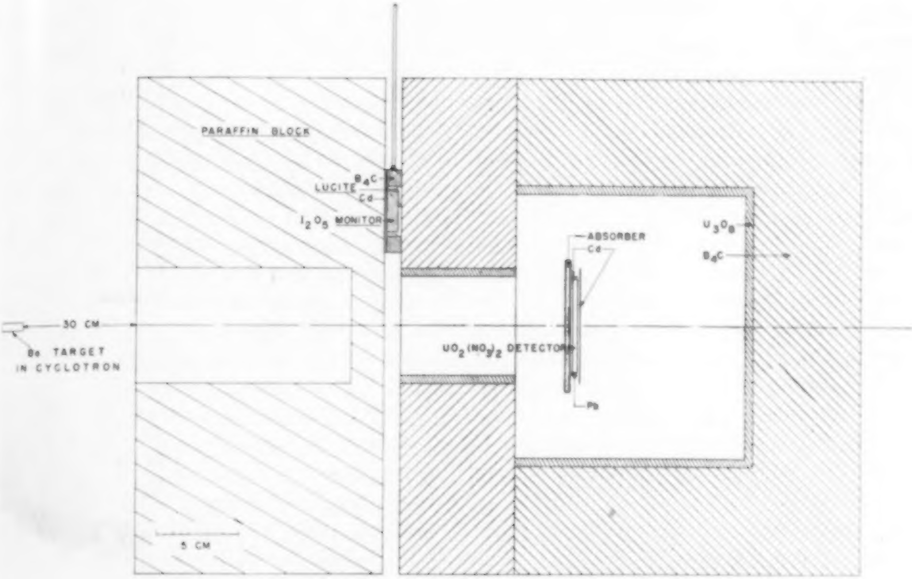
THE problem of how to harness the energy which is released in nuclear reactions has interested scientists for many years. In contrast to chemical reaction, upon which we rely for the greater part of our energy supply, the quantity of material which could be made to undergo a *nuclear* reaction has always been extremely small. The problem took a new turn when last year it was discovered that neutrons could be made to split the uranium nucleus with the release of an enormous amount of energy; for soon after this discovery it was found that the splitting of uranium was accompanied by the emission of secondary neutrons. It became apparent that if, in turn, these secondary neutrons could be made to split other uranium nuclei, the reaction might become self-propagating (chain-reaction) and large quantities of uranium be made to release energy. When a uranium nucleus is split it releases 200,000,000 electron volts, the largest conversion of mass into energy that has yet been produced by terrestrial means; this is to be compared with the energy release of 5 electron volts when a molecule of T.N.T. explodes. However, to bring about a chain reaction it is important that not too many neutrons be lost in an unproductive manner before they have a chance to split uranium. Recent research at Columbia University has thrown light on the way neutrons might be wastefully lost.



COLUMBIA UNIVERSITY CYCLOTRON.
SHOWING THE EXPERIMENTAL ARRANGEMENT FOR STUDYING THE CAPTURE OF NEUTRONS BY URANIUM.

Uranium is split most effectively by slowly moving neutrons; on the other hand, the secondary neutrons which are produced are fairly energetic and must be slowed down before they become effective for splitting. Neutrons may be slowed down by having them collide with some light element like hydrogen. Visualize, therefore, a large mass of a suitable mixture of uranium and water, large enough so that only a few neutrons can escape from the mass and not be utilized. Fast neutrons will then collide with the hydrogen of the water and in each collision lose a part of their energy until they are moving slowly enough to be effective in splitting uranium. However, while being slowed down the neutrons may reach an energy at which they are very readily captured in an unproductive way. Instead of splitting the uranium nucleus, neutrons of about 10 electron volts of energy are captured by uranium to form a radioactive isotope of this substance.

This "wasteful" process has now been studied with the aid of the Columbia 80-ton cyclotron, used as a source of neutrons. The experiments established not only at what energy and over how wide a range were neutrons absorbed in this way, but also how strong was the absorption in this region. The knowledge gained by these measurements will enable physicists to take steps to obviate this "wasteful" consumption of neutrons.



PLAN FOR STUDY OF THE RESONANCE CAPTURE OF NEUTRONS BY URANIUM.

The photograph shows the cyclotron and the experimental arrangement for studying the capture of neutrons by uranium. The neutrons, which instead of splitting the uranium nucleus produce a radioactive isotope, are those having an energy in a narrow band near 10 electron volts. These neutrons are detected by measuring the intensity of the radioactivity which they produce in a thin layer of uranium. They are produced by slowing down in paraffin the neutrons produced in the cyclotron, and can strike the detecting uranium layer through a hole in a thick shield of boron carbide. If a layer of uranium is inserted in the path of the neutrons a decrease in the radioactivity of the detector will be observed, which indicates how strongly these neutrons are absorbed in this unproductive manner. The experimenter is seen inserting the detector in its place behind a uranium absorber. A cylinder of boron carbide is then pushed forward so as to protect the detector from stray neutrons.

HERBERT L. ANDERSON
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IS ATOMIC POWER AT HAND?

Is atomic power at hand? The flood of reports which have swept the country telling of the isolation of the rare isotope of uranium with mass 235, and the possible implications of this discovery for releasing atomic power, make it desirable that some one sit down, take off the gloves, separate fact from fancy and give a fair picture of what is happening in the laboratories in America and Europe. Here are the facts. Fantasy may come later.

1. Over a year ago, when it was first discovered that uranium and thorium atoms could be split by bombardment with neutrons—neutral atomic particles—and made to release a large measure of atomic energy, it was found that

uranium would undergo fission with both "fast" neutrons of high energies and with "slow" neutrons of low energy.

Based on this experimental discovery Professor Niels Bohr, Danish Nobelist, then at the Institute for Advanced Study at Princeton, N. J., and Dr. John A. Wheeler, of Princeton University, suggested that the fast- and slow-neutron splitting of uranium might be due to the presence of two uranium isotopes. The rarer kind of uranium, having mass 235, they suggested, would be split by the very weakly energetic "slow" neutrons. Only "fast" neutrons of high energy, they postulated, would be successful in splitting the common form of uranium with mass 238.

2. The occasion for the recent spectacular newspaper retelling of the story of uranium fission, which has been followed closely in scientific journals and in the press since January, 1939, was the confirmation of the Bohr-Wheeler hypothesis for uranium 235 by Dr. A. O. Nier, of the University of Minnesota, and Drs. E. T. Booth, J. R. Dunning and A. V. Grosse, of Columbia University.

3. Dr. Nier made possible this confirmation by isolating, with a mass spectrometer, a tiny sample of uranium 235, consisting of only a few millionths of a gram of material. Other scientists, including Drs. K. H. Kingdon and H. C. Pollock, of the Laboratories of the General Electric Company, have been effecting similar concentrations of uranium 235 and uranium 238, its heavy common isotope. Professor J. W. Beams, using a gold-plated centrifuge at the University of Virginia, has been working on the problem and is having the material he has isolated checked in a mass spectrometer to determine its atomic weight. At Johns Hopkins University Dr. R. D. Fowler and his colleagues are using a thermal diffusion apparatus to effect the separation of uranium 235 from uranium 238.

4. The isolation of the uranium 235 isotope is extremely slow, tedious and costly in time and effort. Figures discussed by Drs. Kingdon and Pollock reveal that even for the much more abundant uranium isotope of mass 238 it takes three hours of operation to produce one and eight-tenths of a microgram, where a microgram is a millionth of a gram and a gram is less than one four-hundredth of a pound.

Simple computation shows that at this rate it will take scientists some 70,000 days (over 191 years) to make a single gram of concentrated uranium 238 and over 400 times as long—over 75,000 years—to make a pound of this material. The rare isotope of uranium of mass 235, occurring in only one part in 139 in comparison with uranium 238, would take still longer for its production.

5. Preliminary indications, not yet conclusively confirmed in America, point to the presence of a chain reaction in uranium fission with neutrons. In January of 1940 this evidence was reported from Paris by the co-Nobelist scientists, Professor F. Joliot and his colleague, Dr. H. von Halban. It is the chain reaction which is the key to any useful application of uranium fission as a possible source of atomic energy.

So much for the facts about uranium's fission which, unembellished, are seemingly prosaic. Much better reading—and the cause of the wide-spread use of the recent story—is the speculation about the future of the possible release of atomic energy from uranium.

Taking off from fact into fancy one may cite the following:

1. The separation methods for the isolation of uranium 235 are bound to improve, so that while it may take over 75,000 years to concentrate a pound of uranium 235 to-day, it may be done far more quickly in the future.

For one thing, if the ratio of concentration of uranium 235 to uranium 238 is now only 1 to 139, as has recently been reported, the problem is not greatly dif-

ferent from the separation of heavy and light nitrogen isotopes. Of all the ways of isotope separation known, the thermal diffusion method seems potentially best adapted to the separation of uranium 235 in quantity. If any one can figure out a way to spin one of the thermal diffusion columns in a centrifuge so that the two methods may be combined, then the way may be cleared for a fast and effective separation of the two uranium isotopes and physicists may yet get their wish for a 5-pound sample of uranium 235 to work with.

2. It may not be necessary to have pure uranium 235 (U–235) to find practical uses. True, the U–235 works best with the weak neutrons, but uranium 238, much more common, splits with fast, high-energy neutron bombardment. It may be recalled that the discovery of uranium fission was obtained with uranium oxide—a commonplace chemical compound widely spread throughout the earth.

3. The energy liberated from uranium by fission is enormous, and weight for weight it is at least 5,000,000 times as effective as coal.

4. If the chain reaction of having one uranium atom split and liberate the neutrons which will split another one nearby, and so on, can be controlled, then a compact power source for military purposes could be achieved despite whatever the cost might be. Things which are uneconomical in a peacetime sense become practical for military services if they can perform tasks not possible, or carried out as easily, in any other way. No price can be put on such developments that might save the life of a nation that owned the discovery, any more than one can put a price on a surgical operation which saves a man's life.

5. Is Germany pressing the utilization of the discovery of uranium fission? The answer is "probably yes," for it has been pointed out since the first announcement of the sensational find that Germany was the home of the original discovery, and that German scientists have had a six months and more start on their research.

Technically, this is true, but the great uncertainty of Hahn and Strassmann in Germany during the initial stages of their work probably means that the six months' start has been virtually wasted and that American research, particularly, has caught up and perhaps excelled German research in this field.

The drive to find ways of applying the discovery of uranium fission is going on in all nations. Americans should realize that the research does not require the special large cyclotrons and other atom smashers which dominate the American scientific scene.

The whole virtue of uranium fission, aside from any possible practical application, is that it does not require huge apparatus to set off the fissions and release the energy. A little bit of radium mixed in a flask with beryllium and embedded in a block of paraffin is the entire "source" that is required. This radium-beryllium mixture emits neutrons that may be used to bombard uranium, the uranium splitting and its own chain reaction does the rest.

These five points are the fancy which may or may not come true within our time. There are others, like the uranium bomb, which go beyond fancy into the fantastic. One would be a fool to say that these possibilities will not happen, when it is less than two years ago that talk of atomic power was relegated to talk of perpetual motion, ancient medieval alchemy and the search for the philosopher's stone.

It should be realized by all atomic power zealots, however, that even if the chain reaction in uranium fission were conclusively proved and atomic power were a fact to-day, there would still be enormous engineering problems to be conquered in constructing useful machines that could utilize the atomic power.

There are still many unsolved difficulties in uranium fission. It is not outside the realm of possibility that there may be some yet unrecognized process in which slow neutrons, striking uranium 235, are captured and are thus not productive of the vital fission phenomenon. This process of simple capture has been discovered with uranium 238. It may also exist in uranium 235.

Probably the sanest forecast of the future is that uranium atomic power will be so valuable, when and if it comes, that it will be used only for the most special purposes for which it is characteristically adapted and which it can do better than anything else.

Still nearer reality as a forecast is the discovery that uranium fission will have its greatest benefits as a ready-at-hand, compact source of neutrons which are highly sought after in medicine and biological experiments and in nuclear physics. At present huge and costly atom smashers are necessary to create these neutrons for experiments. If the chain reaction can be started and controlled in uranium, every university laboratory could have its own neutron source. The benefits to research on understanding the structure of atoms—and hence all matter—would be immeasurably enhanced by this advance.

NOTE: Newest word from Europe to *Nature* (London, May 9) comes from Stockholm, where Professor Krasny-Ergen reports that the war in Scandinavia has made it necessary for him to stop construction of a thermal diffusion apparatus for the concentration of the rare isotope of uranium of mass 235 which holds the possibility of speeding up, more than 10,000 times, the yield of this isotope. Professor Krasny-Ergen calculates yields of 1.3 milligrams of uranium 235 per day from his apparatus. This means that with a single thermal diffusion tube he could obtain a gram of uranium 235 in about three years. Present production by mass spectrometers in America would require over 33,000 years for the same amount. It is entirely possible to run a whole series of thermal diffusion tubes in tandem, or individually, and greatly speed up the yield still further.

ROBERT D. POTTER

SCIENCE SERVICE

THE MILKY DISEASE vs. THE JAPANESE BEETLE

UTILIZATION of biological control for insect pests seizes upon the imagination of layman and scientist alike. In the case of the former, there is an element of "let George do it" in his attitude—coupled with a blind confidence in results developed from the reading of over-enthusiastic accounts in non-scientific literature.

The scientist, on the other hand, approaches the problem as "a consummation devoutly to be wished." but with a full realization that the use of natural enemies is beset with many "ifs," any one of which may prevent the full measure of success.

In the Maryland Japanese beetle program, an attempt is being made to retard the multiplication and spread of the beetle by trapping on a large scale in the heavily infested areas of the state, by spraying trees and shrubbery in towns, the treatment of soil with arsenate of lead on lawns and golf greens, and by the utilization of parasitic insects, nematodes and the milky white disease discovered by the late G. F. White, of the Bureau of Entomology and Plant Quarantine.

In this retardation program, which is a cooperative effort among federal, state, county and municipal governmental agencies aided by commodity and farm organizations and individuals, great progress has been made in the education of the public to do its part in furthering the campaign. At the same time, 100,000 traps caught last year over 104 tons of beetles, and with 50,000 more traps this year it is anticipated larger totals will be caught this summer.

However, the biotic potential of the

AN ADULT JAPANESE BEETLE.

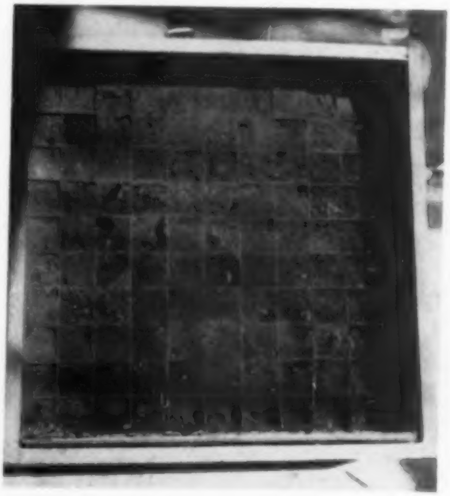
pest is so great that even the catching of such large tonnage can not be expected to complete the subjugation of the insect. But if an effective biological complex can be established there is a good prospect that this imported pest may be reduced to the status of some of our native noxious insects, most of which do only local or sporadic damage that can be checked by the control practices of individuals.

The disease is called the milky white disease because the grubs turn opaque and later die when invaded by the disease. Under experimental conditions, better than 80 per cent. of the grubs in treated areas have succumbed to the disease. There is a probability that the disease is responsible for a general reduction of beetles in the older infested areas.

The disease is caused by a spore-forming bacillus that is extremely resistant to the effects of heat, cold, moisture and desiccation, so its chances of survival in the soil are remarkably good. When optimum conditions occur, such as high concentration of grubs and the best conditions of temperature and moisture, it is quite probable that this disease may become an important factor in the reduction of this pest.

The technique of handling this disease is interesting, and, while the present methods are time-consuming, the cost of treatment per acre is so much lower than arsenate of lead grub-proofing of soil that its use is economically practicable. The method is to collect grubs, inject each with the spores, incubate the inoculated grubs, macerate them when they contain the maximum number of spores, mix the spores with talc and spread the talc on the land.

Beginning last November Maryland workers collected a quarter of a million grubs by the first of December. These were stored in wire-bottom trays, 1,000 grubs per tray, in a cold storage room



INCUBATING BOX CONTAINING FIVE HUNDRED GRUBS.

at 45° F. Unless the grubs are kept dormant by cold they are likely to nip their neighbors, resulting in a big loss in usable grubs. In February inoculation of the individual grubs was begun and at the present time all the first quarter of a million grubs have been inoculated.

Each grub is given a shot into the dorsal segments with a hypodermic needle loaded with a standardized suspension of spores. Each grub gets approximately 2 million spores in about one seventh of a drop of distilled water. This injection is made under a binocular microscope with a special micro-syringe actuated by a screw governed by an escapement that regulates the number of turns of the screw. It is remarkable that each worker soon learns to inject about 1,500 grubs per day with little injury to the grubs, and achieves a final efficiency up to 70 per cent.

After injection each grub is placed in an inch-square compartment in the incubating boxes in soil in which red top and clover seed are mixed. Each box contains 500 grubs. The boxes are then placed in an incubating room held at a temperature of 85° and a high moisture content. The seed germinates, furnishing food for the grubs, and in ten to twelve days the 2 million spores have multiplied to between 2 and 5 billion spores per grub. The majority of the grubs remain alive, however, and at the expiration of the incubation period they are removed and those showing milky disease are stored in ice water until a sufficient quantity has been accumulated for the next step. This step is the grinding of the grubs with the adhering water into a concentrated suspension of spores. Counts in a Levy chamber determine the number of spores per cubic centimeter, and this material is then mixed with precipitated chalk into a dust of known spore concentration per gram and then combined with talc for bulk, so that it may be distributed evenly and in fairly definite spore concentrations on the land that is known to harbor plenty of Japanese beetle grubs. The distribution is made at the rate of 2 pounds of dust containing about 75 billion spores per acre.

The plan of distribution is to cover as rapidly as possible and as the material is available all the heavily infested areas in the state. These areas have been blocked off in square miles in each of which three acres will be treated in the first round. Another one-half million grubs is now being collected which will be used to prepare more spore material for the second round of treatments. The Maryland workers plan to treat approximately 2,000 square miles of heavily infested territory this spring. Then spore preparation will be discontinued until this year's grubs have attained sufficient size to be usable. About next November the process will be renewed and continued until sufficient dust has been prepared to treat every acre in the state that has a high enough grub count to be suitable for rapid dissemination of the spores.

The outlook is good—possibly too good to be true, but in a campaign to reduce the ravages of any serious pest, no method that offers promise can be overlooked. Biological methods, if they work satisfactorily, are permanent, relatively cheap and Maryland hopes that the milky white disease may in this large scale experiment prove to be the answer to a serious and perplexing problem.

ERNEST N. CORY

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THE SCIENTIFIC MONTHLY

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Edited by J. McKEEN CATTELL, F. R. MOULTON and WARE CATTELL

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RECENT BOOKS OF SCIENTIFIC INTEREST

Mr Tompkins in Wonderland. G. GAMOW. Illustrated. 101 pp. $2.00. 1940. Macmillan.

Mr Tompkins, presented as a prosaic little bank cashier, goes to three lectures on modern physics (these are included in the appendix) and as a result has some scientific dreams, by which the author aims to make clear a number of physical principles to nonphysicists.

Development of the Minkowski Geometry of Numbers. H. H. HANCOCK. xiv + 839 pp. $12.00. Macmillan.

New channels for mathematical investigation are initiated, with an aim toward leading to discoveries in fields which are as yet unknown. By repetition of processes involved in solving theorems, the author attempts to make mathematical science easier to conceive and develop.

The Story of Flying. A. BLACK. Illustrated. xv + 267 pp. $2.75. April, 1940. Whittlesey.

An account of the development of aviation, beginning with the story of Icarus and coming down to present-day transport planes. Trends and significant innovations in all types of aircraft are emphasized rather than personalities or individual episodes.

The Photographic Process. MACK and MARTIN. Illustrated. xvii + 586 pp. $5.00. McGraw-Hill.

This book is illustrated and designed to give the reader an understanding of the principles and basic techniques of the photographic process, sufficient to make his practice of photography an intelligent application of principles, rather than a blind following of rules of thumb.

Field Book of Animals in Winter. A. H. MORGAN. Illustrated. xv + 527 pp. $3.50. Putnam.

Winter lives of many animals are described and their methods for meeting physical conditions of temperature change, of feeding, breeding, growth, migration and hibernation are treated in detail. Most of the animals discussed are presented pictorially by drawings and photographs.

Elementary Photography. G. G. QUARLES. x + 350 pp. $3.00. 1940. McGraw-Hill.

Designed to be intermediate between elementary high school texts and technical treatises, this text discusses the historical background of photography, physical principles, camera parts, taking pictures, developing, color photography and lantern slides.

Natural History of the Birds of Eastern and Central North America. E. H. FORBUSH. Revised edition. xxv + 554 pp. $4.95. 1939. Houghton Mifflin.

A detailed account of all birds in the eastern and central United States, discussing their identification, voice and breeding and range. There are 96 plates, each showing several specimens, by Louis Agassiz Fuertes, Allan Brooks and Roger Tory Peterson.

The Notebooks of Leonardo da Vinci. Edited by E. McCURDY. Illustrated. 1247 pp. $5.00. Reynal and Hitchcock. 1939.

The first wholly American edition of the translation of da Vinci's notebooks. The notebooks are presented as a kind of mental autobiography of the Florentine painter. The manuscripts extend over a period of about forty years, from early manhood to old age.

Books previously announced will be given space six times on this page for $12.00


THE WASHINGTON
Scene

THE JUNE SCIENTIFIC MONTHLY

Edited by

J. McKEEN CATTELL, F. R. MOULTON AND
WARE CATTELL

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NEW BOOKS OF SCIENTIFIC INTEREST

Living Light. E. N. HARVEY. Illustrated. vi+328 pp. $4.00. May, 1940. Princeton.

A non-technical treatise on the production of light by organisms in six chapters: Cold Light; Light-Producing Organisms; Types of Luminescence; Chemistry of Light Production; Physiology of Light Production; Physical Nature of Animal Light.

Photographic Facts and Formulas. E. J. WALL. Revised by F. I. Jordan. xxv + 384 pp. $2.50. 1924. 1940. American.

This is a handbook for photographers, giving working directions and formulae for commonly used photographic processes. It is intended as a compact guide for the busy photographer who needs plain and concise facts with which to work.

The Book of Diamonds. J. W. HERSHEY. Illustrated. xii + 142 pp. $2.00. 1940. Hearthside.

This non-technical volume opens with the history of diamonds and superstitions connected with them. Other sections are devoted to properties and tests, advice on buying and using diamonds and to a description of methods of synthesizing them.

General College Chemistry. J. A. BABOR and A. LEHRMAN. 2d ed. Illustrated. xiv + 659 pp. $3.75. February, 1940. Crowell.

This college text-book approaches chemistry from the point of view of atomic physics. Chemical reactions and solutions are then discussed, and the remainder of the volume examines the properties of various elements and their uses.

Basic Course in Botany. R. J. POOL. Illustrated. xx + 654 pp. $3.75. 1940. Ginn.

The author of this book has attempted to emphasize the essentials of the science and to present the phenomena associated with plants as features of the dynamic cosmos as a whole, with the terminology and classification made as simple and as brief as possible.

Desert Wild Flowers. E. C. JAEGER. Illustrated. 322 pp. $3.50. March, 1940. Stanford University.

For twenty-five years the author of this book has been trekking over the deserts of the Southwest, sketch pad and pencil in hand. Seven hundred and sixty-four desert plants are described and illustrated in photographs or line drawings. This book contains general natural history material as well.

The Physiographic Provinces of North America. W. W. ATWOOD. Illustrated. xi + 536 pp. $4.80. 1940. Ginn.

A general discription of the geographic divisions is first given. The author then proceeds to enlarge upon certain areas and to describe the physiographic make-up of the sub-provinces. He concludes each section with a review and an "approach to the Human Drama."

Preclinical Medicine. M. W. THEWLIS. vii + 223 pp. $3.00. February, 1939. Williams and Wilkins.

A handbook for medical men discussing the determination of diseases before they reach the clinical stage. Genetics, constitution, susceptibility, transmission of diseases and early symptoms are discussed in reference to a number of specific ailments.

Race, Language and Culture. F. BOAZ. Illustrated. xx + 647 pp. $5.00. February, 1940. Macmillan.

A collection of the author's anthropological writings over a period of half a century, discussing problems connected with race, language and culture, particularly by examining their manifestations in civilizations and nations other than our own.

Sex and Life. E. STEINACH. Illustrated. x + 252 pp. $3.75. January, 1940. Viking.

A review of work conducted by the author in the field of sex-hormones, both in animals and human beings. While not intended as a text-book, it discusses in detail his techniques for "rejuvenation" and the results of his glandular experiments.

The Invasion from Mars. H. CANTRIL. xiv + 228 pp. $2.50. April, 1940. Princeton.

A study in the psychology of panic based on an analysis of reactions to the "War of the Worlds" broadcast of Orson Welles in the fall of 1938. The complete script of the program is included.

Wild Bird Neighbors. A. M. PETERSON. Illustrated. xxxiii + 283 pp. $2.00. 1940. Bruce.

Here are informal sketches which give glimpses into the home and social life of thirty-five North American wild birds. The author writes of their appearance, mating habits, nests, eggs, young, protective habits, food, songs and their economic value.

The Road to Modern Science. H. A. REASON. Illustrated. xiv + 297 pp. $3.00. March, 1940. Appleton-Century.

A popular account of the history of science, emphasizing scientific discoveries and the backgrounds against which they were made. The account is chronological until 1600, and after that date recounts the development of individual sciences.

Modern Methods and Materials for Teaching Science. E. D. HEISS, E. S. OSBOURN and C. W. HOFFMAN. Illustrated. x + 351 pp. $2.50. January, 1940. Macmillan.

This volume discusses the aims and psychology of science teaching. Considerable space is devoted to visual aids in teaching science, and particularly to a catalogue of pictures, models, charts, films and publications available to teachers.

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